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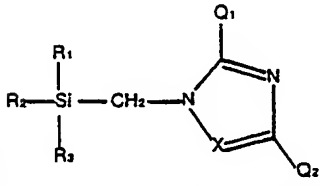
(54) Fungicidal 1,2,4-triazole and imidazole derivatives.

(57) 1,2,4-Triazole and imidazole derivatives of the general formula



wherein R_1, R_2 and R_3 are alkyl, naphthyl or optionally substituted phenyl; or R_2 and R_3 may be hydroxy or alkoxy;
X is N, CH or CCH_3; and
Q_1 and Q_2 are H or CH_3;
are effective fungicides for controlling fungi in a plant locus. They may be formulated for use in conventional manner.

The compounds may be made e.g. by reacting a suitable chloromethylsilane with a suitable imidazole or 1,2,4-triazole.

EP 0 068 813 A2

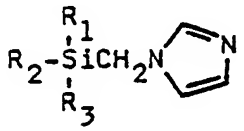
Title BA-8453-B (Cognate)

FUNGICIDAL 1,2,4-TRIAZOLE AND IMIDAZOLE DERIVATIVES

Background of the Invention

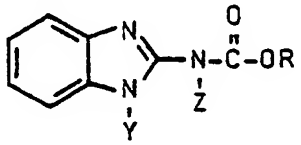
The present invention relates to silylmethyl-triazoles and imidazoles such as, for example, dimethyl(phenyl)(1H-1,2,4-triazol-1-ylmethyl)silane and (1,1'-biphenyl-4-yl)dimethyl(1H-imidazol-1-ylmethyl)-silane, and to the use of these new compounds, in controlling fungus diseases, particularly diseases of living plants.

U.S. Patent 3,692,798 discloses compounds of the formula:



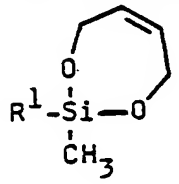
wherein R_1, R_2 and R_3 can be lower alkyl and phenyl. It is stated that these compounds are useful as antimicrobial agents.

European Patent 29,993 discloses compounds of the formula:



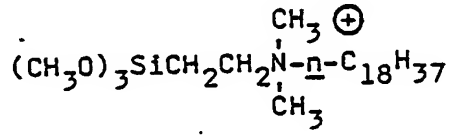
wherein R can be C_1-C_4 alkyl and Y and Z can be H or $SiR_1R_2R_3$, wherein R_1, R_2, and R_3 can be alkyl, haloalkyl, alkenyl, alkynyl, or substituted phenyl. It is taught that the compounds are useful as agricultural fungicides.

U.S. Patents 3,256,308 and 3,337,598 disclose compounds of the formula:



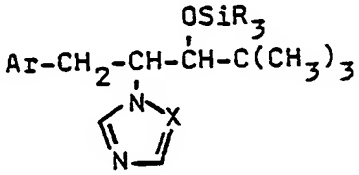
wherein R_1 can be methyl, ethyl, vinyl, or phenyl. Their use to control fungi is also taught.

Belgian Patent 785,127 discloses quaternary ammonium salts such as:



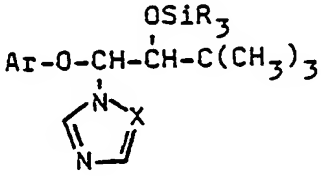
and their use as fungicides.

Research Disclosure 17,652 discloses silyl ethers of the formula:



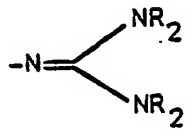
wherein Ar can be substituted phenyl, X can be CH or N, and R can be alkyl. It is taught that the compounds are useful as agricultural fungicides.

West German Patent DE 3,000,140 discloses silyl ethers of the formula:



wherein Ar can be substituted phenyl, X can be CH or N, and R can be phenyl or lower alkyl. It is taught that these compounds are useful as agricultural fungicides.

U.S. Patent 4,248,992 discloses a class of organosilicon compounds having in a molecule at least one monovalent guanidine group represented by the general formula:



in which R is a hydrocarbon atom or a monovalent hydrocarbon group. These guanidine-containing organosilicon compounds are described as useful as antifungal agents for molded plastics and rubbers, particularly silicone rubbers.

U.S.S.R. Patent 346,306 discloses silylmethylazoles of the formula:

$$(R_1)_n(R_2O)_{3-n}SiCH_2Az$$

wherein R_1 and R_2 are alkyl groups, n is 0-3, and Az is a pyrazole, imidazole, or benzimidazole ring, optionally substituted.

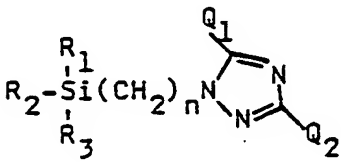
U.S.S.R. Patent 271,552 discloses silylethylazoles of the formula:

$$(R_1)_n(R_2O)_{3-n}SiCH_2CH_2Az$$

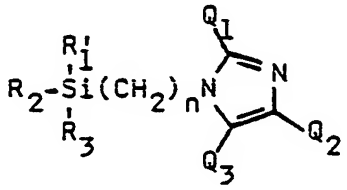
wherein R_1, R_2, n, and Az are as described in the previous reference.

Summary of the Invention

This invention relates to silylmethyltriazoles of Formula I and to silylmethylimidazoles of Formula II and to agriculturally useful compositions of these compounds.



I



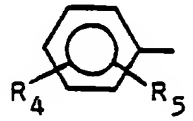
II

wherein

Q_1, Q_2 and Q_3 are independently H or CH_3;

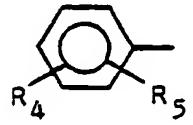
n is 1;

R_1 is C_2-C_{18} alkyl, C_3-C_6 cycloalkyl, naphthyl, or



;

R'_1 is C_6-C_{18} alkyl, C_3-C_6 cycloalkyl, naphthyl or



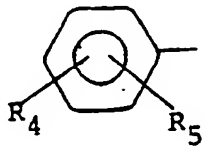
;

where

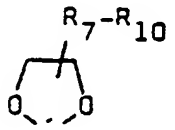
R_4 and R_5 are independently -H; halogen; $-OCH_3$; $-OCF_3$; $-SCH_3$; $-SO_2CH_3$; phenyl; phenyl substituted with halogen and/or C_1-C_4 alkyl and/or $-CF_3$; phenoxy; phenoxy substituted with halogen and/or C_1-C_4 alkyl and/or $-CF_3$; $-CF_3$; C_1-C_4 alkyl; or cyclohexyl;

with the proviso that for compounds of Formula II, both R_4 and R_5 may not simultaneously be H; and

R_2 and R_3 are independently C_1-C_6 alkyl, C_3-C_6 cycloalkyl, OR_6, or



where R_4 and R_5 are as defined above except that said proviso does not apply, and R_6 is H or C_1-C_4 alkyl, with the proviso that both R_2 and R_3 may not be OH; and R_2 and R_3 together may be a 1,2- or 1,3- or 1,4-glycol bridge or a 1,4 unsaturated glycol bridge substituted by up to four alkyl groups R_7-R_{10} that have a total of up to four carbon atoms.



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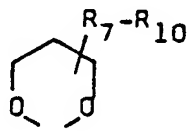

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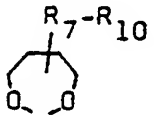

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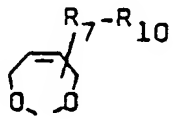
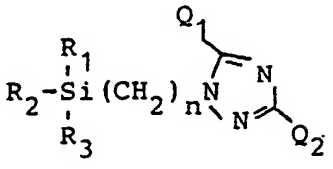
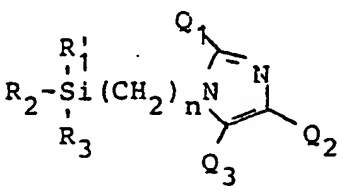


This invention also relates to a method for controlling fungus diseases, particularly fungus diseases of living plants which comprises applying to the locus to be protected an effective amount of a compound of formula I or formula II



I



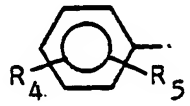
II

wherein

Q_1, Q_2 and Q_3 are independently H or CH_3;

n is 1;

R_1 and R'_1 are C_2-C_{18} alkyl, C_3-C_6 cycloalkyl, naphthyl, or

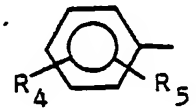


;

where

R_4 and R_5 are independently -H; halogen; $-OCH_3$; $-OCF_3$; $-SCH_3$; $-SO_2CH_3$; phenyl; phenyl substituted with halogen and/or C_1-C_4 alkyl and/or $-CF_3$; phenoxy; phenoxy substituted with halogen and/or C_1-C_4 alkyl and/or $-CF_3$; $-CF_3$; C_1-C_4 alkyl; or cyclohexyl;

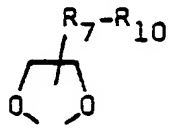
R_2 and R_3 are independently C_1-C_6 alkyl, C_3-C_6 cycloalkyl, OR_6, or



;

where R_6 is H or C_1-C_4 alkyl,

with the proviso that both R_2 and R_3 may not be OH; and R_2 and R_3 together may be a 1,2- or 1,3- or 1,4-glycol bridge or a 1,4 unsaturated glycol bridge substituted by up to four alkyl groups R_7-R_{10} that have a total of up to four carbon atoms.



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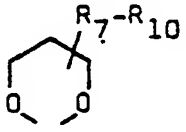

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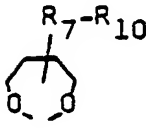

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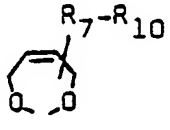
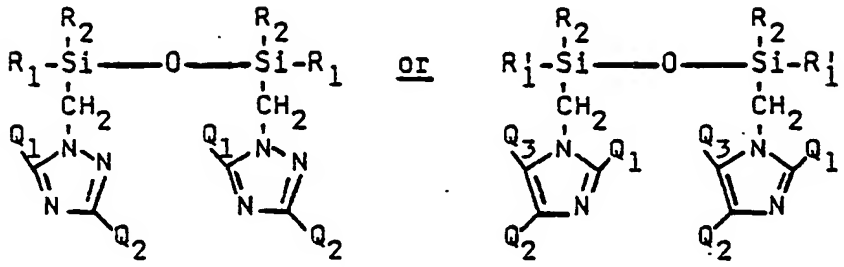


When R_2 or R_3 is OH, Formula I and Formula II are understood to include the disiloxane:

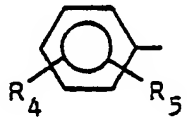


This invention also relates to salts of compounds of Formula I and Formula II with protic acids and complexes with metal ions.

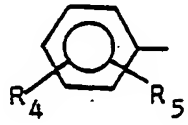
Preferred for their high activity and/or favorable ease of synthesis are compounds of the generic scope wherein

$Q_1 = Q_2 = H$.

More preferred for their higher activity and/or more favorable ease of synthesis are compounds of the preferred scope wherein

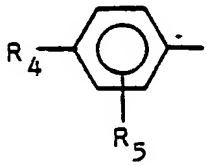
R_1 and R_1' are  ; and

R_2 is C_1-C_4 alkyl or

 ; and

R_3 is C_1-C_4 alkyl.

Most preferred for their highest activity and/or most favorable ease of synthesis are compounds of the more preferred scope wherein

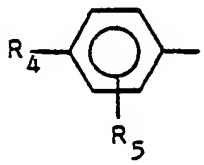
R_1 and R_1' are  ;

where

R_4 is at the para position of R_1 or R'_1, and R_4 is H, F, Cl, Br, or phenyl, and

R_5 is H, F, Cl_2 or Br; and

R_2 is



or C_1-C_4 alkyl; and

R_3 is C_1-C_4 alkyl.

Specifically preferred for their excellent activity and/or most favorable ease of synthesis are the following compounds of Formula I:

(Dimethyl)phenyl(1H-1,2,4-triazol-1-ylmethyl)silane;

Dimethyl(4-methylphenyl)(1H-1,2,4-triazol-1-ylmethyl)-silane;

(4-Bromophenyl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)-silane;

(1,1'-Biphenyl-4-yl)dimethyl(1H-1,2,4-triazol-1-yl-methyl)silane;

(4-Chlorophenyl)dimethyl(1H-1,2,4-triazol-1-yl-methyl)silane;

(2,4-Dichlorophenyl)dimethyl(1H-1,2,4-triazol-1-yl-methyl)silane;

Butyl(4-chlorophenyl)methyl(1H-1,2,4-triazol-1-yl-methyl)silane;

bis(4-Chlorophenyl)methyl(1H-1,2,4-triazol-1-yl-methyl)silane;

Methyl(diphenyl)(1H-1,2,4-triazol-1-ylmethyl)silane;

[bis(4-Fluorophenyl)]methyl(1H-1,2,4-triazol-1-yl-methyl)silane;

(4-Fluorophenyl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)-silane;

Butyl(2,4-dichlorophenyl)methyl(1H-1,2,4-triazol-1-yl-methyl)silane;

[bis(2,4-Dichlorophenyl)]methyl(1H-1,2,4-triazol-1-yl-methyl)silane;

2,4-Dichlorophenyl(methyl)phenyl(1H-1,2,4-triazol-1-yl-methyl)silane;

4-Chlorophenyl(methyl)phenyl(1H-1,2,4-triazol-1-yl-methyl)silane;

4-Fluorophenyl(methyl)phenyl(1H-1,2,4-triazol-1-yl-methyl)silane;

Butyl(methyl)phenyl(1H-1,2,4-triazol-1-ylmethyl)silane;

Butyl(4-fluorophenyl)methyl(1H-1,2,4-triazol-1-yl-methyl)silane;

[bis(1,1'-Biphenyl-4-yl)]methyl(1H-1,2,4-triazol-1-ylmethyl)silane;

(1,1'-Biphenyl-4-yl)butyl(methyl)(1H-1,2,4-triazol-1-ylmethyl)silane; and

(1,1'-Biphenyl-4-yl)methyl(phenyl)(1H-1,2,4-triazol-1-ylmethyl)silane.

Especially preferred compounds, methods, and compositions of Formula II are those compounds wherein at least one group R_1, R_2 or R_3 is other than lower alkyl (C_1-C_4) or phenyl. In particular, the following compounds of Formula II are specifically preferred for their excellent activity and/or most favorable ease of synthesis:

(1,1'-Biphenyl-4-yl)dimethyl(1H-imidazol-1-ylmethyl)-silane;

(2,4-Dichlorophenyl)dimethyl(1H-imidazol-1-ylmethyl)-silane;

Butyl(2,4-dichlorophenyl)(1H-imidazol-1-ylmethyl)-methylsilane;

[bis(4-Fluorophenyl)](1H-imidazol-1-ylmethyl)methyl-silane;

[bis(2,4-Dichlorophenyl)](1H-imidazol-1-ylmethyl)-methylsilane;

(2,4-Dichlorophenyl)(1H-imidazol-1-ylmethyl)methyl-(phenyl)silane;

(4-Chlorophenyl)(1H-imidazol-1-ylmethyl)methyl(phenyl)-silane;

(4-Fluorophenyl)(1H-imidazol-1-ylmethyl)methyl(phenyl)-silane;

(1,1'-Biphenyl-4-yl)butyl(1H-imidazol-1-ylmethyl)-methylsilane;

(1,1'-Biphenyl-4-yl)(1H-imidazol-1-ylmethyl)methyl-(phenyl)silane;

[bis(1,1-Biphenyl-4-yl)](1H-imidazol-1-ylmethyl)methyl-silane;

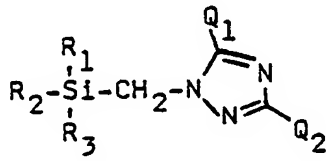
Butyl(4-chlorophenyl)(1H-imidazol-1-ylmethyl)methyl-silane;

(4-Chlorophenyl)dimethyl(1H-imidazol-1-ylmethyl)-silane;

Dimethyl(4-fluorophenyl)(1H-imidazol-1-ylmethyl)-silane; and

Butyl(4-fluorophenyl)(1H-imidazol-1-ylmethyl)methyl-silane.

When Q_1 and Q_2 are both H or both CH_3, the process for preparing the triazole derivatives of Formula I will ordinarily produce a mixture of two triazole isomers:



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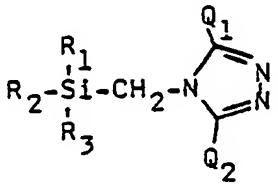
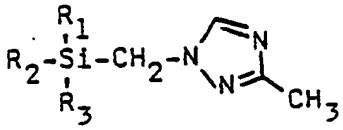


Formula IA Formula IB

Three isomers are possible when one triazole substituent is H and the other is CH_3:



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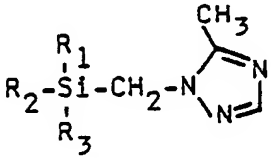
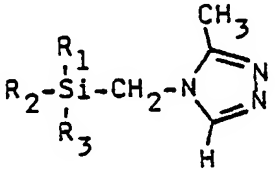


Formula IC Formula ID

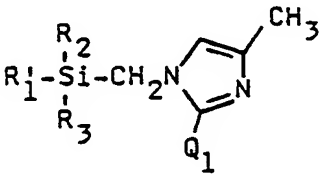
and



Formula IE

The mixture will contain predominately the isomers of Formula IA or Formula IC; however, the isomers of Formulae IB, ID, and IE also have fungicidal activity, and separation of the isomers is not required.

For the imidazole derivatives of Formula II, isomers are produced when Q_2 and Q_3 are not the same:



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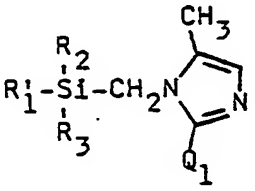


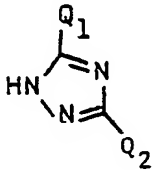
Formula IIA

Formula IIB

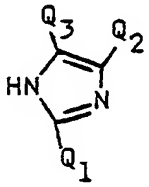
The isomers of Formula IIA will generally predominate; however, the isomer of Formula IIB also has fungitoxic activity and separation of the isomers is not required.

Detailed Description of the Invention

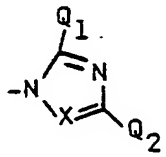
In the following discussion, R_1 is understood to represent both R_1 and R_1', since all values of R_1' are included in the definition of R_1. Further, the term "azole" will be used to refer to appropriately substituted 1,2,4-triazoles and imidazoles



and



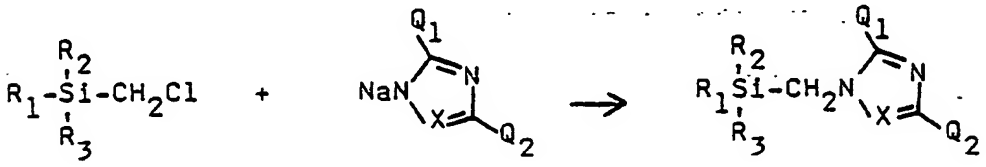
where Q_1, Q_2 and Q_3 may be H or CH_3. In drawing structural formulas, the part-structure



where X is N or CQ_3 will be used to denote both triazole and imidazole ring systems.

Synthesis

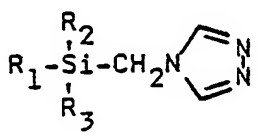
The compounds of this invention can be prepared from chloromethylsilanes and 1,2,4-triazole or imidazole sodium salt or their methylated homologs:



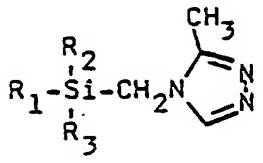
Lithium and potassium azole salts may also be used. Bromomethylsilanes, iodomethylsilanes, or arylsulfonyloxymethylsilanes may be used instead of chloromethylsilanes. Roughly equimolar amounts of the reagents are used (except when $R_3 = OR_6$; see below), with the azole salt often taken in 5-10% excess of theory. In addition, 1,2,4-triazole or imidazole themselves can be used if an acid acceptor is added. Suitable acceptors include excess azole, alkali metal alkoxides such as sodium methoxide or potassium tert-butoxide, inorganic bases such as potassium carbonate, or sodium hydride, and tertiary amines such as triethylamine. When the acid acceptor is a good nucleophile, such as sodium methoxide, an excess should be avoided to prevent undesired side reactions. Suitable solvents include polar aprotic solvents such as dimethylformamide, dimethyl sulfoxide, or acetonitrile; ethers such as tetrahydrofuran or 1,2-dimethoxyethane; and ketones such as 2-butanone. The reaction temperature can vary between 0° and 200°C, preferably between 25° and 100°C. The reaction can be conducted under elevated pressure, but it is generally preferable to operate at atmospheric pressure. The optimum temperature and reaction time will vary with the concentra-

tion and choice of reagents, and especially with the choice of solvent. For example, 1,2,4-triazole and sodium methoxide at roughly 2 molar concentration in dimethylformamide gives good conversion in approximately 2 hours at 80-90°C, whereas 1,2,4-triazole and potassium carbonate at roughly 1 molar concentration in 2-butanone requires 8-12 hours at reflux. The imidazole reactions are generally more rapid. In general, reaction times of 1 to 24 hours are required. Progress of the reaction can be followed by working up aliquots for nmr analysis and following the intensities of the starting material $SiCH_2Cl$ singlet near 2.9 and the product $SiCH_2N$ singlets, which are near 3.8 for compounds of Formula I and near 3.7 for compounds of Formula II.

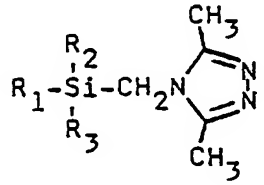
With respect to the triazole derivatives of Formula I, the 1H-1,2,4-triazol-1-ylmethyl compound as prepared above is accompanied by a minor amount of the isomeric 4H-1,2,4-triazol-4-ylmethyl compound:



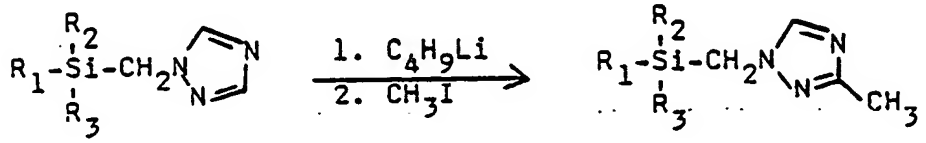
The ratio of isomers varies with values of R and reaction conditions, with a 1-substituted to 4-substituted ratio of roughly 10:1 often observed. The mono- and dimethyltriazoles give similar 4H-isomers as minor products:



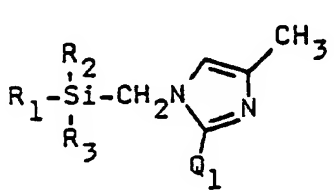
or



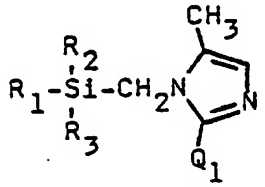
When the unsubstituted silylmethyltriazole is available, metalation-methylation provides an alternate synthesis of the methylated homologs:



With respect to the imidazole derivatives of Formula II, isomers are possible only when Q_2 and Q_3 are not the same. Two isomers result:



and

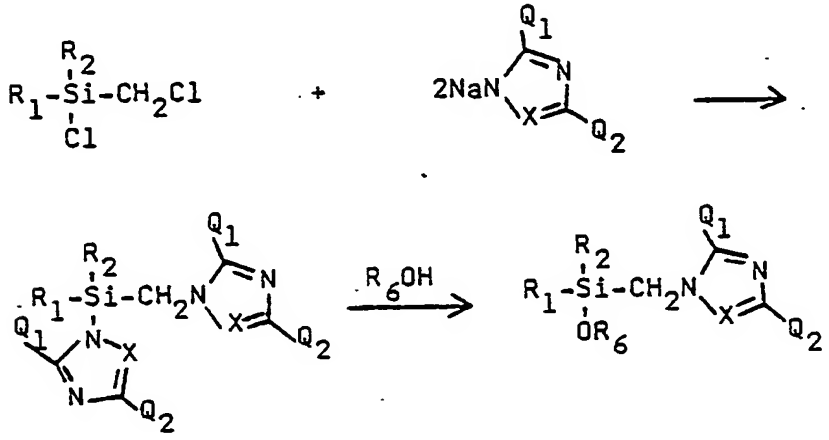


Formula IIA

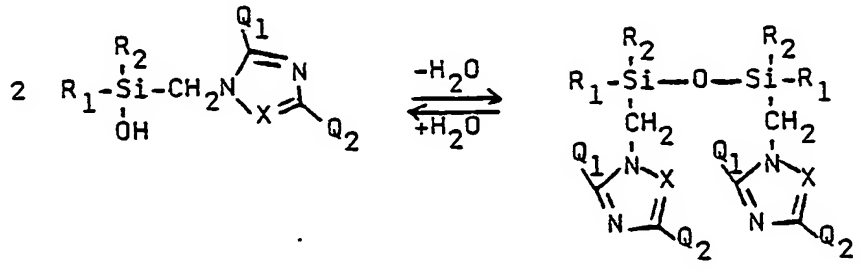
Formula IIB

The product of Formula IIA will generally predominate. If desired, the isomers may be separated by standard techniques such as crystallization, distillation, or chromatography.

For the case where $R_3 = OR_6$ in the triazole or imidazole product, the chlorines of a chloro(chloromethyl)silane can be replaced in one of two ways. In one method, at least two equivalents of the azole sodium salt can be used. An intermediate containing a very reactive silicon-azole bond forms, and reaction with water or an alcohol gives the desired oxygenated compounds:

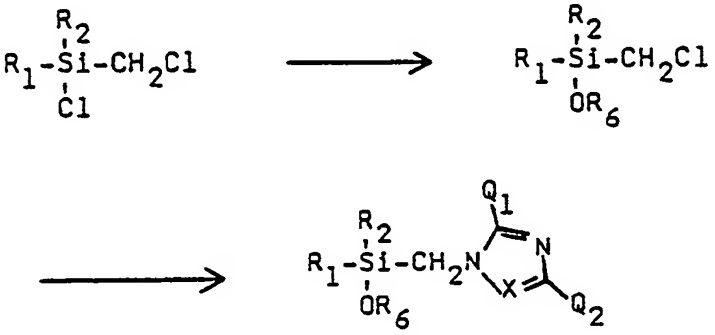


Suitable solvents and reaction conditions are the same as those outlined on pages 11, 12 and 13 for azole displacements. The temperature of alcoholysis is not critical, and warming to 50-100°C can be used to ensure complete reaction when $R_6 = C_1$-C_4 alkyl. For $R_6 = H$, however, hydrolysis is best conducted near room temperature to minimize disiloxane formation, recognizing that silanol-disiloxane equilibrium is possible whenever $R_6 = H$:



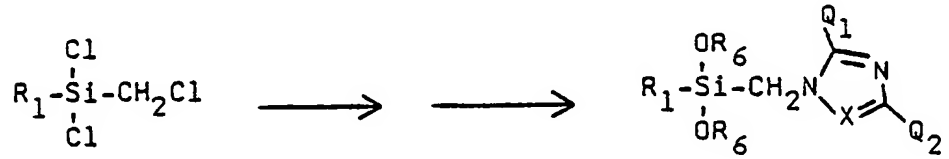
The position of equilibrium and the rate at which it is established will vary with the values of R_1 and R_2, solvent, temperature, and the presence or absence of acidic or basic catalysts.

In the second method, the silicon-oxygen bond is formed first, followed by azole displacement as described earlier:



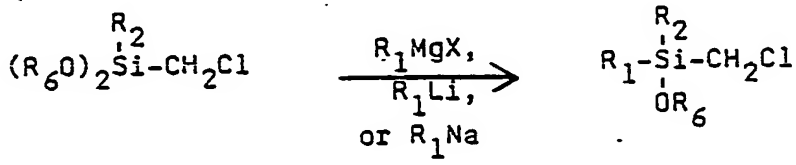
Reaction of the chlorosilane with R_6OH may be conducted in almost any non-hydroxylic solvent, with ethers such as diethyl ether, 1,2-dimethoxyethane, and tetrahydrofuran or dipolar aprotic solvents such as dimethylformamide and acetonitrile being preferred. Although an acid acceptor is not required, it is preferred to add a tertiary amine such as triethylamine or pyridine. The reaction temperature may vary from 0° to 100°C, and R_6OH is often taken in excess of theory. The combination of 2 equivalents of R_6OH, 1.1 equivalents of triethylamine, and 0.1 equivalents of imidazole in dimethylformamide at 80° for two hours has been broadly applicable.

Extending these methods to (chloromethyl)dichlorosilanes provides dioxygenated silanes:



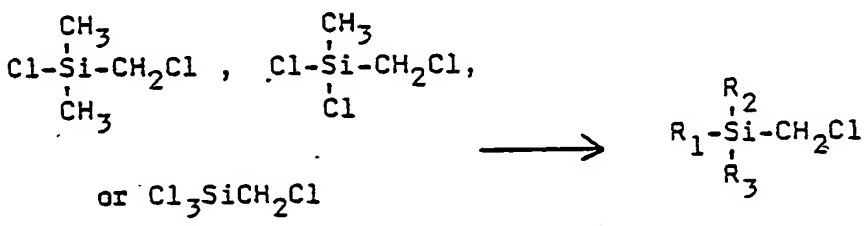
Glycol derivatives are formed similarly, using a diol instead of two molecules of R_6OH.

An alternative synthesis for alkoxy(chloromethyl)silanes involves selective replacement of one alkoxy group of a dialkoxysilane with an organometallic reagent:



Conditions for this displacement are as described in the next paragraph, with the added stipulation that the organometallic should be added to the dialkoxysilane.

The required chloromethylsilane starting materials are made from commercially available chloro(chloromethyl)dimethylsilane, chloromethyl(dichloro)methylsilane, or chloromethyltrichlorosilane:



The Si-Cl bonds in these compounds react with organolithium, organosodium, or Grignard reagents to introduce alkyl and/or aryl groups according to literature procedures, leaving the C-Cl bond intact. For the silanes containing two or three Si-Cl bonds, stepwise replacements are possible, giving considerable flexibility to the values of R_1-R_3. Bromosilanes, iodosilanes, or alkoxysilanes may be substituted for chlorosilanes in these reactions. Preferred solvents for these reactions include ethers such as tetrahydro-

furan, 1,2-dimethoxyethane, and diethyl ether, or hydrocarbons such as hexane and toluene. The preferred temperature will vary between -80° and 40° depending on the nature of the organometallic reagent, how it was generated, and the solvent. For example, when aryllithium reagents are generated in tetrahydrofuran from aryl bromides using butyllithium, the mixture should be held below roughly -40° to avoid side reactions involving the bromobutane produced. If the organometallic solution is stable at higher temperatures, however, reactions may be run at -20° to 25° without competing reaction of the CH_2Cl group. The reaction is rapid at all temperatures, and only a short period, for example 30 to 60 minutes, is required after the reagents are combined to ensure complete reaction.

Reactions of $ClSi(CH_3)_2CH_2Cl$ with Grignard reagents are described by C. Eaborn and J. C. Jeffrey, J. Chem. Soc., 1954, 4266; and a recent review on synthesis of aryltrimethylsilanes from $ClSi(CH_3)_3$, which contains experimental procedures useful for $ClSi(CH_3)_2CH_2Cl$ reactions, is that of D. Habich and F. Effenberger, Synthesis, 1979, 841. Selective introduction of one new alkyl group into $Cl_2Si(CH_3)CH_2Cl$ is described by V. P. Kuznetsova and R. M. Sokolovaskaya, Zh. Obshch. Khim., 1969, 1977; Chem. Abstr., 72, 31897 p; and one aryl group may be introduced selectively as well:

In both cases the organometallic reagent should be added to the dichlorosilane at low temperature with good mixing for best yields.

Reactions of Cl_3SiCH_2Cl with Grignard reagents are described by A. A. Zhdanov, V. I. Pakhomov, and T. Bazhanova, Zh. Obshch. Khim., 1973, 1280; Chem. Abstr., 79, 66452 m. Adding organometallic reagents to the trichlorosilane is recommended even when three identical groups are being introduced, because adding Cl_3SiCH_2Cl to an organometallic reagent is not usually successful. A single aryl group may also be introduced:

$$Cl_3SiCH_2Cl + ArLi \longrightarrow Ar\text{-}\underset{\displaystyle Cl}{\overset{\displaystyle Cl}{\overset{|}{\underset{|}{Si}}}}\text{-}CH_2Cl$$

A useful modification of literature procedures, applicable when R_1 or R'_1 is an aryl group, has been developed in the present work. Instead of preforming an organolithium reagent and then combining it with a chlorosilane, it has been found that an aryl bromide and a chlorosilane such as $ClSi(CH_3)_2CH_2Cl$ may be combined in an inert solvent such as tetrahydrofuran and treated at -80 to -40° with butyllithium. Bromine-lithium exchange proceeds selectively, and the resulting aryllithium reacts with the Si-Cl bond as it is formed:

$$ArBr + Cl\text{-}\underset{\displaystyle CH_3}{\overset{\displaystyle CH_3}{\overset{|}{\underset{|}{Si}}}}\text{-}CH_2Cl \xrightarrow[-C_4H_9Br]{n\text{-}C_4H_9Li} \left[ArLi + Cl\text{-}\underset{\displaystyle CH_3}{\overset{\displaystyle CH_3}{\overset{|}{\underset{|}{Si}}}}\text{-}CH_2Cl \right]$$

$$\xrightarrow{-LiCl} Ar\text{-}\underset{\displaystyle CH_3}{\overset{\displaystyle CH_3}{\overset{|}{\underset{|}{Si}}}}\text{-}CH_2Cl$$

This reaction works equally well for aryl-substituted chlorosilanes such as $ClSi(CH_3)(C_6H_5)CH_2Cl$, and it can be used to introduce two aryl groups into $Cl_2Si(CH_3)CH_2Cl$. In a further extension, an aryl and an n-butyl group may be introduced in one step:

$$ArBr + Cl_2\overset{CH_3}{\overset{|}{Si}}-CH_2Cl \xrightarrow{2n\text{-}C_4H_9Li} Ar-\overset{CH_3}{\overset{|}{\underset{n\text{-}C_4H_9}{\underset{|}{Si}}}}-CH_2Cl$$

Substitution of other alkyllithiums RLi for n-butyllithium provides a general route to $Ar(CH_3)Si(R)CH_2Cl$.

In the following examples, temperatures are reported in degrees Celsius. Abbreviations for nuclear magnetic resonance (nmr) spectra are s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet; peak positions are reported as parts per million downfield from internal tetramethylsilane. Infrared (ir) peak positions are given in reciprocal centimeters (cm^{-1}). Hexanes refers to the mixture of isomers boiling 68-69°, and ether refers to diethyl ether.

Example 1

Preparation of (1,1'-Biphenyl-4-yl)(chloromethyl)-dimethylsilane

A solution of 9.9 g (0.042 mol) of 4-bromobiphenyl in 50 ml of dry tetrahydrofuran was cooled to -78° under nitrogen and stirred while 26.5 ml (0.042 mol) of 1.6 molar n-butyllithium in hexane was added dropwise over 15 minutes. A thick slurry formed, and 35 ml of tetrahydrofuran was added to facilitate stirring. With continued cooling, 5.9 ml (6.7 g, 0.046 mol) of chloro(chloromethyl)dimethylsilane was added over 10 minutes, giving a clear solution that was allowed to warm to room temperature. Addition of 300 ml of ether, filtration to remove precipitated lithium chloride, and evaporation of the filtrate left 13.2 g of semisolid. Redissolution in ether, filtration, and evaporation of the filtrate left 11.0 g (100% crude) of the title compound as a colorless solid, m.p. 30-40°, suitable for further reaction. Trace impurities could be removed by sublimation at 30°/0.1 mm, leaving the title compound unsublimed in 83% recovery: m.p. 37-40°; ir (Nujol^{R}) 1585, 1240, 1110, 830, 810, 750, 690 cm^{-1}; nmr ($CDCl_3$) 0.4 (6H, s), 2.9 (2H, s), 7.3-7.7 (9H, m).

Example 2

Preparation of (4-Bromophenyl)(chloromethyl)dimethylsilane

4-Bromophenylmagnesium bromide was prepared from 11.8 g (0.050 mol) of 1,4-dibromobenzene and 1.2 g (0.050 g-atom) of magnesium turnings in 75 ml of ether according to G. P. Schiemenz, Org. Syn., Coll. Vol. 5, 496 (1973). The resulting mixture was chilled in ice under a nitrogen atmosphere while a solution of 6.6 ml (7.2 g, 0.050 mol) of chloro(chloromethyl)dimethylsilane in 10 ml of ether was added dropwise. The reaction mixture was then stirred overnight at room temperature, quenched carefully with saturated aqueous ammonium chloride, and filtered. The ether phase of the filtrate was washed with brine, dried over magnesium sulfate, and evaporated to leave 9.8 g of an oil. Distillation gave 3.8 g (29%) of the title compound as a colorless liquid: bp 97° (1 mm); ir (neat) 2950, 1575, 1475, 1370, 1250, 1065, 1010, 840, 805, 720 cm^{-1}; nmr ($CDCl_3$) 0.4 (6H, s), 2.9 (2H, s), 7.3-7.7 (4H, m).

Example 3

Preparation of Chloromethyl(4-chlorophenyl)dimethylsilane

A solution of 9.6 g (0.050 mol) of 4-bromochlorobenzene and 6.6 ml (7.2 g, 0.050 mol) of chloro(chloromethyl)dimethylsilane in 75 ml of tetrahydrofuran was stirred at -78° under nitrogen while 31 ml (0.050 mol) of 1.6 molar n-butyllithium in hexane was added dropwise. The resulting clear solution was allowed to warm to room temperature, diluted with ether until no more lithium chloride precipitated, and filtered. Evaporation of the filtrate left 10.6 g of a light yellow liquid, which was distilled to give 6.0 g (55%) of the title compound as a colorless liquid: bp 54-58°C (0.05 mm); ir (neat) 2910, 1560, 1470, 1370, 1250, 1080, 1010, 840, 805, 790, 740 cm^{-1}; nmr ($CDCl_3$) 0.4 (6H, s), 2.9 (2H, s), 7.1-7.6 (4H, q).

The in situ aryllithium generation described in this example is also useful for preparing the product of Example 1. If the reaction is run at 0.5-0.7 molar in 4-bromobiphenyl and the temperature is held at -65 to -55°C during butyllithium addition, little or no solid precipitates.

Example 4

Preparation of Chloromethyl(2,4-dichlorophenyl)-dimethylsilane

A solution of 17.0 g (0.075 mol) of 2,4-dichlorobromobenzene and 10.8 ml (11.8 g, 0.082 mol) of chloro(chloromethyl)dimethylsilane in 100 ml of dry tetrahydrofuran was chilled to -70° under nitrogen and stirred while 49 ml (0.079 mol) of 1.6 molar n-butyllithium in hexane was added dropwise at a rate that held the mixture below -70°. The resulting cloudy reaction mixture was allowed to warm to room temperature, poured into 400 ml of hexanes, filtered, and evaporated to leave 20.5 of yellow liquid. Distillation gave 12.6 g (66%) of the title compound as a colorless liquid: bp 83° (0.02 mm); n_D^{24} 1.5522; ir (neat) 1565, 1455, 1360, 1255, 1120, 1100, 1040, 825 cm^{-1}; nmr ($CDCl_3$) 0.5 (6H, s), 3.1 (2H, s), 7.0-7.5 (3H, m).

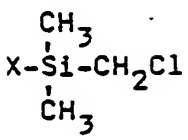
Example 5

Preparation of Chloromethyl(2,6-dimethoxyphenyl)-dimethylsilane

A solution of 25.0 g (0.181 mol) of 1,3-dimethoxybenzene in 250 ml of tetrahydrofuran was stirred at room temperature under nitrogen while 125 ml (0.200 mol) of 1.6 molar n-butyllithium in hexane was added dropwise over 30 minutes. The resulting mixture was refluxed 1.5 hour, giving an orange-brown solution that was cooled to 5° and stirred while 27 ml (29.4 g, 0.205 mol) of chloro(chloromethyl)dimethylsilane was added dropwise over 15 minutes. The resulting white suspension was allowed to warm to room temperature, stirred there 1 hour, diluted with ethyl acetate, poured into water, and extracted with ether. The organic layers were washed with brine, dried over magnesium sulfate, and distilled to give 37.0 g (84%) of the title compound as a colorless liquid: bp 98-110° (0.1 mm); nmr ($CDCl_3$) 0.4 (6H, s), 3.1 (2H, s), 3.7 (6H, s), 6.3 (2H, d), 7.1 (1H, m).

By varying the organolithium or Grignard reagent, the procedures of Examples 1-5 can be used to prepare the compounds of Table I. Closely related procedures are also known in the literature, for example the use of arylmagnesium chlorides by C. Eaborn and J. C. Jeffrey, J. Chem. Soc., 1954, 4266. For compounds where R_1 is a phenyl ring bearing a 2-halo substituent, an alternative to the in situ procedure of Example 4 is the special arylmagnesium iodide method of C. Eaborn, K. L. Jaura, and D. R. M. Walton, J. Chem. Soc., 1964, 1198.

Table I



X = R_1 or R_1'	
C_2H_5	bp 127-128°
n-C_4H_9	bp 172°
n-$C_{12}H_{25}$	n_D^{23} 1.4510
n-$C_{18}H_{37}$	n_D^{22} 1.4556
cyclopropyl	
cyclopentyl	
cyclohexyl	bp 120-130° (10 mm)
1-naphthyl	bp 112° (0.08 mm)
2-naphthyl	
phenyl	bp 85-86° (3 mm)
4-fluorophenyl	bp 59-60° (0.1 mm)
4-methoxyphenyl	bp 80° (0.05 mm)
4-phenoxyphenyl	bp 122° (0.03 mm)
4-(4-chlorophenoxy)phenyl	n_D^{22} 1.5773
4-(4-fluorophenoxy)phenyl	
4-(4-trifluoromethylphenoxy)phenyl	
4-(4-methylphenoxy)phenyl	
4-thiomethylphenyl	bp 92-93° (0.05 mm)
4-trifluoromethylphenyl	n_D^{23} 1.4686
4-methylphenyl	bp 96° (7 mm)
4-i-propylphenyl	
4-t-butylphenyl	n_D^{23} 1.5056
4-methylsulfonylphenyl	m.p. 64-68°
4-cyclohexylphenyl	n_D^{21} 1.5424
4-trifluoromethoxyphenyl	bp 55-57° (0.15 mm)
4-(4-chlorophenyl)phenyl	
4-(4-bromophenyl)phenyl	

Table I (continued)

X = R_1 or R_1'	
4-(4-methylphenyl)phenyl	
4-(4-trifluoromethylphenyl)phenyl	
4-(4-fluorophenyl)phenyl	
3-phenylphenyl	n_D^{20} 1.5862
3-trifluoromethylphenyl	bp 59-62° (0.3 mm)
3-chlorophenyl	bp 73° (0.15 mm)
2-trifluoromethylphenyl	n_D^{23} 1.4826
2-phenylphenyl	n_D^{20} 1.5772
2-chlorophenyl	bp 78-80° (0.3 mm)
2-methoxyphenyl	n_D^{21} 1.5164
2,3-dimethylphenyl	
2,3-dimethoxyphenyl	n_D^{22} 1.5254
2,4-difluorophenyl	
2-fluoro-4-chlorophenyl	
2-chloro-4-phenylphenyl	
2-fluoro-4-phenylphenyl	
2-methyl-5-chlorophenyl	
2,6-dimethylphenyl	
3,4-dichlorophenyl	bp 98° (0.6 mm)
3-methyl-4-fluorophenyl	
3,5-dichlorophenyl	bp 94-95° (0.25 mm)

Example 6

Preparation of (1,1'-Biphenyl-4-yl)butyl(chloromethyl)-methylsilane

The title compound can be prepared by the procedure of Example 1 by substituting (butyl)chloro(chloromethyl)methylsilane for chloro(chloromethyl)dimethylsilane.

Related compounds can be prepared by the procedures of Examples 1-5, using the appropriate organolithium or Grignard reagent and $Cl(R_2)Si(CH_3)CH_2Cl$. The required chloromethylsilane starting materials are made from R_2MgCl or R_2Li and $Cl_2Si(CH_3)CH_2Cl$ according to Examples 14 and 15, and literature procedures such as V. P. Kuznetsova and R. M. Sokolovaskaya, Zh. Obshch. Khim., 1969, 1997.

Alternatively, both the biphenyl and butyl groups can be introduced simultaneously as follows: A solution of 23.3 g (0.10 mol) of 4-bromobiphenyl and 12.7 ml (16.4 g, 0.10 mol) of chloromethyl(dichloro)-methylsilane in 150 ml of dry tetrahydrofuran was chilled under nitrogen to -70° and stirred while 125 ml (0.20 mol) of 1.6 molar n-butyllithium in hexane was added at a rate that held the mixture below -60°C. The resulting thin slurry was allowed to warm to room temperature, treated cautiously with 10 ml of ethyl acetate, and poured into 300 ml of water. The organic layer was separated, the aqueous phase was washed with another 100 ml of hexanes, and the combined organic phases were washed three times with water, once with brine, dried over magnesium sulfate, and evaporated to leave 33.9 g of a viscous yellow oil. Distillation gave 9.5 g (31%) of the title compound: bp 135-158° (0.1 mm); n_D^{22} 1.5743; ir (neat) 3060, 3015, 2960, 2920, 2870, 1600, 1485, 1390, 1380, 1250, 1120, 1075, 1005, 875, 810, 800, 760, 700 cm^{-1}; nmr ($CDCl_3$): 0.4 (3H, s), 0.6-1.8 (9H, m), 2.9 (2H, s) and 7.0-7.7 (9H, m).

Example 7

Preparation of Butyl(chloromethyl)(4-chlorophenyl)-methylsilane

A solution of 14.4 g (0.075 mol) of 4-bromochlorobenzene and 9.5 ml (12.3 g, 0.075 mol) of chloromethyl(dichloro)methylsilane in 150 ml of tetrahydrofuran was cooled to -60° under nitrogen and stirred while 94 ml (0.15 mol) of 1.6 molar n-butyllithium in hexane was added dropwise at a rate that held the mixture between -65 and -55°. The resulting slurry was allowed to warm to room temperature, giving a solution that was diluted with hexanes until no more lithium chloride precipitated. Filtration, evaporation of the filtrate, dissolution of the residue in hexanes, refiltration, and evaporation left 19.8 g of a pale orange liquid. Distillation gave first 1.8 g (12%) of chloromethyl(dibutyl)methylsilane, bp 45°C (0.05 mm), followed by 6.8 g (35%) of the title compound as a colorless liquid: bp 90°C (0.05 mm); n_D^{21} 1.5246; ir (neat) 2925, 1580, 1380, 1260, 1090, 1015, 820, 740 cm^{-1}; nmr ($CDCl_3$) 0.4 (3H, s), 0.6-1.5 (9H, m), 2.9 (2H, s), 7.0-7.4 (4H, q).

Example 8

Preparation of Chloromethyl(2,4-dichlorophenyl)methyl-(phenyl)silane

A solution of 13.6 g (0.060 mol) of 2,4-dichlorobromobenzene and 12.3 g (0.060 mol) of chloro(chloromethyl)methyl(phenyl)silane (prepared as in Example 14) in 85 ml of dry tetrahydrofuran was chilled to -60° under nitrogen and stirred while 38 ml (0.060 mol) of 1.6 molar n-butyllithium in hexane was added dropwise at a rate that held the mixture below -55°. The resulting red solution was allowed to warm to room temperature, treated with 5 ml of ethyl acetate to quench any unreacted organolithium reagent, and poured into 170 ml of water. The organic layer was separated, the aqueous phase was washed with 50 ml of hexanes, and the combined organic phases were washed three times with water and once with brine, dried over magnesium sulfate, and evaporated to leave 19.0 g of bright yellow oil. Distillation gave 8.6 g (45%) of the title compound as a colorless liquid: b.p. 125-130° (0.05 mm); n_D^{21} 1.5978; ir (neat) 3080, 3060, 2960, 2930, 1570, 1540, 1460, 1430, 1365, 1260, 1120, 1100, 1040, 820, 745, 735, 705 cm^{-1}; nmr ($CDCl_3$) 0.8 (3H, s), 3.4 (2H, s), 7.2-7.9 (8H, m).

Example 9

Preparation of Chloromethyl[bis(4-chlorophenyl)]methylsilane

A solution of 19.1 g (0.10 mol) of 4-chlorobromobenzene in 200 ml of dry tetrahydrofuran was chilled to -60° under nitrogen and stirred while 63 ml (0.10 mol) of 1.6 molar n-butyllithium in hexane was added dropwise at a rate that held the mixture below -55°. Stirring and cooling were continued while 6.3 ml (8.2 g, 0.05 mol) of chloromethyl(dichloro)methylsilane was added dropwise at a rate that held the mixture below -50°. The resulting orange solution was allowed to warm to room temperature, and workup as in Example 8 provided 16.5 g of a pale yellow oil. Kugelrohr distillation at 0.05 mm and an airbath temperature of 130-150°C gave 9.5 g (60%) of the title compound as a colorless liquid: n_D^{24} 1.5913; ir (neat) 3080, 3040, 3020, 2960, 2930, 1580, 1490, 1380, 1260, 1085, 1015, 805, 790, 775, 740 cm^{-1}; nmr ($CDCl_3$) 0.7 (3H, s), 3.1 (2H, s), 7.2-7.7 (8H, m); analysis for $C_{14}H_{13}Cl_3Si$ (mw 315.70):

Calculated:	C, 53.26;	H, 4.15;	Cl, 33.69.
Found:	C, 53.4;	H, 4.4;	Cl, 34.2.
	53.5;	4.4;	34.1.

Example 10

Preparation of (Chloromethyl)bis(4-fluorophenyl)methylsilane

A solution of 35 g (0.20 mol) of 4-fluorobromobenzene in 300 ml of dry tetrahydrofuran was chilled to -60° under nitrogen and stirred while 126 ml (0.20 mol) of 1.6 molar n-butyllithium in hexane was added dropwise at a rate that held the mixture below -55°. Stirring and cooling were continued while 12.6 ml (16.4 g, 0.10 mol) of chloromethyl(dichloro)methylsilane was added dropwise at a rate that held the mixture below -50°. The resulting solution was allowed to warm to room temperature, and workup as in Example 8 provided 26.4 g of a clear yellow liquid. Distillation gave 20.6 g (73%) of the title compound as a colorless liquid: bp 107-127° (0.1 mm); n_D^{22} 1.5481; nmr ($CDCl_3$): 0.7 (3H, s), 3.2 (2H, s), 7.1 (4H, t, J = 9) and 7.6 (4H, d of d, J = 6 and 9).

Repeating this reaction using chloromethyl(diethoxy)methylsilane instead of the dichlorosilane gave the title compound in 58% yield after distillation: bp 115-138° (0.2 mm); n_D^{21} 1.5464; nmr as above.

Example 11

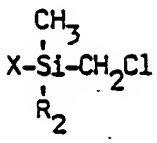
Preparation of Chloromethyl(2-chlorophenyl)(4-chlorophenyl)methylsilane

A solution of 6.3 ml (8.2 g, 0.05 mol) of chloromethyl(dichloro)methylsilane and 8.1 g (0.05 mol) of 2-bromochlorobenzene in 75 ml of dry tetrahydrofuran was chilled to -60° under N_2 and stirred while 31 ml (0.05 mol) of 1.6 molar n-butyllithium-hexane solution was added at a rate that held the mixture below -55°. With continued cooling and stirring, 8.1 g (0.05 mol) of 4-bromochlorobenzene was added as a solid, followed by another 31 ml portion of the 1.6

molar n-butyllithium solution at a rate that held the mixture below -55°C. The resulting thin slurry was allowed to warm to room temperature, treated cautiously with 10 ml of ethyl acetate, and worked up as in Example 8 to give 15.0 g of a clear yellow oil. Distillation provided 5.9 g (37%) of the title compound: bp 150-165° (0.7 mm); n_D^{20} 1.5916; ir (neat) 3060, 3020, 2960, 2920, 2870, 1580, 1560, 1490, 1420, 1380, 1255, 1125, 1115, 1085, 1035, 1015, 805, 750 cm^{-1}; nmr ($CDCl_3$) 0.8 (3H, s), 3.3 (2H, s), 7.2-7.7 (8H, m).

The compounds of Table II are made by stepwise replacement of the Si-Cl bonds of $Cl_2Si(CH_3)CH_2Cl$, according to the procedures of Examples 6-11.

Table II



X = R_1, R_1'	R_2	
C_2H_5	C_2H_5	
i-C_3H_7	cyclohexyl	
n-C_4H_9	n-C_4H_9	bp 45° (0.05 mm)
n-$C_{10}H_{21}$	cyclopropyl	
n-$C_{18}H_{37}$	3-methylbutyl	
cyclopropyl	n-C_6H_{13}	
cyclohexyl	cyclohexyl	
1-naphthyl	t-C_4H_9	
2-naphthyl	n-C_5H_{11}	
phenyl	n-C_3H_7	
phenyl	n-C_4H_9	bp 82-90°(0.1 mm)
phenyl	1,1-dimethylpropyl	
4-phenylphenyl	C_2H_5	
4-bromophenyl	i-C_3H_7	
4-fluorophenyl	n-C_4H_9	bp 90-92°(0.1 mm)
4-phenoxyphenyl	t-C_4H_9	
4-t-butylphenyl	cyclopentyl	
3-trifluoromethylphenyl	s-C_4H_9	
3-chlorophenyl	n-C_5H_{11}	
2-thiomethylphenyl	cyclobutyl	
2-phenylphenyl	i-C_4H_9	
2,4-dichlorophenyl	n-C_4H_9	bp 109-112°(0.1 mm)
2,4-dichlorophenyl	cyclopropyl	
2,3-dimethylphenyl	n-C_3H_7	
2-methyl-5-fluorophenyl	cyclopentyl	
2,5-dimethoxyphenyl	4-methylpentyl	

Table II (continued)

$X = R_1, R_1'$	R_2	
2,6-dimethylphenyl	1-methylbutyl	
3,5-dichlorophenyl	n-C_4H_9	
3,5-dichlorophenyl	cyclohexyl	
3-methyl-4-chlorophenyl	cyclopropyl	
phenyl	phenyl	bp 104-110°(0.2 mm)
4-fluorophenyl	phenyl	n_D^{22} 1.5624
4-chlorophenyl	phenyl	bp 140-148°(0.1 mm)
4-bromophenyl	phenyl	bp 145-155°(0.1 mm)
4-phenylphenyl	phenyl	bp 173-178°(0.1 mm)
4-t-butylphenyl	phenyl	
4-thiomethylphenyl	phenyl	
4-phenoxyphenyl	phenyl	
4-trifluoromethoxyphenyl	phenyl	
4-methylsulfonylphenyl	phenyl	
4-cyclohexylphenyl	phenyl	
4-(4-fluorophenyl)phenyl	phenyl	
3-trifluoromethylphenyl	phenyl	
2-chlorophenyl	phenyl	bp 132-135°(0.1 mm)
2-methoxyphenyl	phenyl	
2-chloro-4-phenylphenyl	phenyl	
2-fluoro-4-phenylphenyl	phenyl	
3,5-dichlorophenyl	phenyl	
2,5-dimethoxyphenyl	phenyl	
2,6-dimethoxyphenyl	phenyl	
4-bromophenyl	4-bromophenyl	bp 160-170°(0.1 mm)
4-phenylphenyl	4-phenylphenyl	m.p. 115-117°
4-methoxyphenyl	4-methoxyphenyl	bp 166-171°(0.1 mm)
3-trifluoromethylphenyl	3-trifluoromethylphenyl	
2-methoxyphenyl	2-methoxyphenyl	
2-chlorophenyl	2-chlorophenyl	bp 135-140°(0.1 mm)
2,4-dichlorophenyl	2,4-dichlorophenyl	n_D^{21} 1.5956
3,5-dichlorophenyl	3,5-dichlorophenyl	

Table II (continued)

$X = R_1, R_1'$	R_2
2-chlorophenyl	4-fluorophenyl
4-phenylphenyl	4-chlorophenyl
4-phenylphenyl	4-fluorophenyl
4-phenylphenyl	2,4-dichlorophenyl
4-fluorophenyl	2,4-dichlorophenyl
4-chlorophenyl	2,4-dichlorophenyl
1-naphthyl	2,6-dimethoxyphenyl
4-phenoxyphenyl	3,4-dichlorophenyl

Example 12

Preparation of (1-1'-Biphenyl-1-yl)(chloromethyl)-diethylsilane

The title compound can be prepared by the procedure of Example 1, using chlorochloromethyldiethylsilane instead of chlorochloromethyldimethylsilane.

Similar compounds can be prepared by applying the procedures of Examples 1-5 to the appropriate organolithium or Grignard reagent and $Cl(R_2)Si(R_3)CH_2Cl$. The required chlorochloromethyldialkylsilanes are made from Cl_3SiCH_2Cl, using two equivalents of R_2MgCl or R_2Li when $R_2 = R_3$ (see, for example, A. A. Zhdanov, V. I. Pakhomov, and T. Bazhanova, Zh. Obshch. Khim., 1973, 1280), or using one equivalent of R_2MgCl or R_2Li followed by one equivalent of R_3MgCl or R_3Li when R_2 is not equal to R_3.

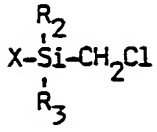
Example 13

Preparation of (Chloromethyl)triphenylsilane

A solution of 12.6 ml (18.4 g, 0.10 mol) of (chloromethyl)trichlorosilane in 150 ml of dry ether was stirred under nitrogen and chilled in ice while 162 ml (0.30 mol) of 1.85 molar phenyllithium in cyclohexane-ether 70:30 was added dropwise at a rate that held the mixture below 15°C. The resulting slurry was stirred overnight at room temperature, treated carefully with 10 ml of ethyl acetate to quench any remaining phenyllithium, washed with water and brine, dried over magnesium sulfate, and evaporated to leave 33 g of sticky solid. Recrystallization from 30 ml of cyclohexane provided 15.8 g (51%) of the title compound as an off white solid: m.p. 112-115°C; ir (Nujol^{R}) 1420, 1110, 735, 730, 705, 695 cm^{-1}; nmr ($CDCl_3$) 3.5 (2H, s), 7.0-7.8 (15H, m).

The compounds of Table III are made by stepwise replacement of the Si-Cl bonds of Cl_3SiCH_2Cl, according to the procedures of Examples 12-13.

Table III



$X = R_1, R_1'$	R_2	R_3
C_2H_5	C_2H_5	C_2H_5
i-C_3H_7	i-C_3H_7	i-C_3H_7
n-C_4H_9	n-C_4H_9	n-C_4H_9
n-C_8H_{17}	C_2H_5	cyclopentyl
n-$C_{14}H_{29}$	cyclopropyl	1-methylbutyl
n-$C_{18}H_{37}$	n-C_6H_{13}	n-C_6H_{13}
cyclopropyl	C_2H_5	s-C_4H_9
cyclohexyl	n-C_3H_7	n-C_3H_7
1-naphthyl	n-C_4H_9	n-C_4H_9
2-naphthyl	n-C_4H_9	cyclobutyl
phenyl	cyclopropyl	n-C_6H_{13}
4-phenylphenyl	n-C_4H_9	n-C_4H_9
4-phenylphenyl	n-C_6H_{13}	n-C_6H_{13}
4-phenylphenyl	cyclohexyl	cyclohexyl
4-chlorophenyl	n-C_4H_9	n-C_4H_9
4-fluorophenyl	n-C_3H_7	n-C_3H_7
4-phenoxyphenyl	n-C_4H_9	cyclohexyl
4-(4-chlorophenoxy)phenyl	n-C_4H_9	n-C_4H_9
4-t-butylphenyl	s-C_4H_9	i-C_4H_9
3-methoxyphenyl	C_2H_5	t-C_4H_9
3-trifluoromethylphenyl	s-C_4H_9	s-C_4H_9
2-thiomethylphenyl	i-C_3H_7	3-methylbutyl
2-phenylphenyl	cyclohexyl	cyclohexyl
2,4-dichlorophenyl	n-C_4H_9	n-C_4H_9
2,6-dimethylphenyl	t-C_4H_9	t-C_4H_9
3,5-dichlorophenyl	cyclopentyl	cyclopentyl
3-methyl-4-chlorophenyl	s-C_4H_9	s-C_4H_9

Table III (continued)

$X = R_1, R_1'$	R_2	R_3
C_2H_5	phenyl	phenyl
cyclohexyl	phenyl	phenyl
n-$C_{18}H_{37}$	phenyl	phenyl
n-C_4H_9	4-chlorophenyl	4-chlorophenyl
n-$C_{12}H_{25}$	4-chlorophenyl	4-chlorophenyl
1-naphthyl	4-fluorophenyl	4-fluorophenyl
cyclopropyl	phenyl	4-t-butylphenyl
n-C_4H_9	phenyl	4-phenylphenyl
t-C_4H_9	phenyl	2,4-dichlorophenyl
n-C_3H_7	phenyl	3-trifluoromethylphenyl
i-C_4H_9	phenyl	3,5-dichlorophenyl
cyclopentyl	phenyl	2,6-dimethoxyphenyl
n-$C_{14}H_{29}$	4-chlorophenyl	2-fluorophenyl
n-C_4H_9	4-fluorophenyl	4-phenylphenyl
4-chlorophenyl	4-chlorophenyl	4-chlorophenyl
4-fluorophenyl	4-fluorophenyl	4-fluorophenyl
4-phenylphenyl	4-phenylphenyl	4-phenylphenyl
2,4-dichlorophenyl	2,4-dichlorophenyl	2,4-dichlorophenyl
phenyl	4-fluorophenyl	4-fluorophenyl
phenyl	4-chlorophenyl	4-chlorophenyl
phenyl	4-phenylphenyl	4-phenylphenyl
phenyl	2,4-dichlorophenyl	2,4-dichlorophenyl
2-naphthyl	4-methylthiophenyl	4-methylthiophenyl
4-chlorophenyl	2-methoxyphenyl	2-methoxyphenyl
4-chlorophenyl	3-chlorophenyl	3-chlorophenyl
phenyl	2-chlorophenyl	4-fluorophenyl
phenyl	4-chlorophenyl	4-phenylphenyl
1-naphthyl	4-bromophenyl	3-methylphenyl
4-phenoxyphenyl	3,5-dimethylphenyl	3,4-dichlorophenyl

Example 14

Preparation of Chloro(chloromethyl)methyl(phenyl)silane

A solution of 12.7 ml (16.4 g, 0.10 mol) of chloromethyl(dichloro)methylsilane in 200 ml of ether was chilled to -70° under nitrogen and stirred vigorously while a mixture of 55 ml (0.10 mol) of 1.8 molar phenyllithium in 30:70 ether-cyclohexane and 55 ml of ether was added dropwise at a rate that kept the mixture below -70°. The resulting slurry was stirred and warmed to room temperature, then allowed to stand overnight. Filtration and evaporation of the filtrate left 20.4 g of a golden oil, which was distilled to give 14.6 g (71%) of the title compound as a colorless liquid: bp 71-74° (0.6 mm); n_D^{23} 1.5337; ir (neat) 3080, 3060, 2980, 2930, 1590, 1430, 1260, 1120, 820, 790, 740, 700 cm^{-1}; nmr ($CDCl_3$) 0.8 (3H, s), 3.1 (2H, s), 7.3-7.6 (3H, m), 7.6-7.8 (2H, m).

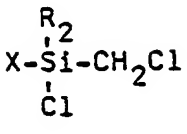
Example 15

Preparation of (1,1'-Biphenyl-4-yl)chloro(chloromethyl)methylsilane

The title compound can be prepared by reaction of equimolar quantities of 4-bromobiphenyl, chloromethyldichloro(methyl)silane, and n-butyllithium according to the procedure of Example 3.

The compounds of Table IV can be prepared using the procedures of Examples 14 and 15.

Table IV



$X = R_1, R_1'$	R_2
C_2H_5	CH_3
$\underline{t}$-C_4H_9	CH_3
$\underline{n}$-C_4H_9	CH_3
$\underline{n}$-$C_{12}H_{25}$	C_2H_5
$\underline{n}$-$C_{18}H_{37}$	$\underline{n}$-C_6H_{13}
cyclopropyl	CH_3
cyclohexyl	CH_3
1-naphthyl	$\underline{i}$-C_3H_7
2-naphthyl	cyclobutyl
phenyl	$\underline{t}$-C_4H_9
4-phenylphenyl	$\underline{n}$-C_4H_9
4-phenylphenyl	$\underline{n}$-C_6H_{13}
4-chlorophenyl	$\underline{n}$-C_4H_9
4-chlorophenyl	CH_3
4-fluorophenyl	$\underline{n}$-C_6H_{13}
4-phenoxyphenyl	cyclohexyl
4-$\underline{t}$-butylphenyl	$\underline{n}$-C_3H_7
4-trifluoromethoxyphenyl	CH_3
4-(4-fluorophenyl)phenyl	CH_3
3-trifluoromethylphenyl	$\underline{t}$-C_4H_9
2-thiomethylphenyl	cyclopentyl
2,4-dichlorophenyl	CH_3
2,4-dichlorophenyl	$\underline{n}$-C_4H_9
2-chloro-4-phenylphenyl	CH_3
2,3-dimethylphenyl	cyclopropyl
2-methyl-5-fluorophenyl	$\underline{s}$-C_4H_9
2,6-dimethoxyphenyl	1,1-dimethylpropyl

Table IV (continued)

$X = R_1, R_1'$	R_2
3-methyl-4-chlorophenyl	C_2H_5
3,5-dichlorophenyl	n-C_5H_{11}
n-$C_{12}H_{25}$	2,4-dichlorophenyl
n-$C_{18}H_{37}$	phenyl
1-naphthyl	phenyl
phenyl	phenyl
4-fluorophenyl	phenyl
4-chlorophenyl	phenyl
4-phenylphenyl	phenyl
4-t-butylphenyl	phenyl
3-fluorophenyl	phenyl
2-methoxyphenyl	phenyl
2-chlorophenyl	phenyl
2,4-dichlorophenyl	phenyl
3,5-dichlorophenyl	phenyl
4-fluorophenyl	4-fluorophenyl
4-chlorophenyl	4-chlorophenyl
4-phenylphenyl	4-phenylphenyl
2,4-dichlorophenyl	2,4-dichlorophenyl
3-trifluoromethylphenyl	3-trifluromethylphenyl
2-methoxyphenyl	2-methoxyphenyl
2-chlorophenyl	4-fluorophenyl
3-trifluoromethylphenyl	4-t-butylphenyl
2-fluoro-4-chlorophenyl	4-bromophenyl
2,3-dimethylphenyl	4-methylthiophenyl
2,6-dimethoxyphenyl	4-methoxyphenyl
3,4-dichlorophenyl	4-methylphenyl

Example 16

Preparation of Chloromethyl(methoxy)methyl(phenyl)-silane

A solution of 1.6 ml (1.3 g, 0.040 mol) of methanol and 3.0 ml (2.2 g, 0.022 mol) of triethylamine in 100 ml of ether was stirred while a solution of 4.1 g (0.020 mol) of chloro(chloromethyl)methyl(phenyl)silane in 10 ml of ether was added dropwise. The resulting slurry was refluxed for 2 hours, cooled, washed with water, 0.1 N aqueous HCl, saturated aqueous $NaHCO_3$, water, and brine, dried over magnesium sulfate, and evaporated to leave 3.2 g of a pale yellow liquid. Distillation provided 1.7 g (42%) of the title compound as a colorless liquid: bp 46-49° (0.05 mm); n_D^{22} 1.5207; nmr ($CDCl_3$): 0.5 (3H, s), 3.0 (2H, s), 3.5 (3H, s) and 7.3-7.8 (5H, m).

Example 17

Preparation of Chloromethyl(1,1-dimethylethoxy)methyl(phenyl)silane

A mixture of 15.4 g (0.075 mol) of chloro(chloromethyl)methyl(phenyl)silane, 14 ml (11.1 g, 0.15 mol) of t-butanol, 11.5 ml (8.3 g, 0.082 g) of triethylamine, and 0.5 g (0.008 mol) of imidazole in 60 ml of dimethylformamide was stirred at 80° for 2 hours. The resulting slurry was cooled, poured into 200 ml of water, and extracted with ether. The ether extracts were washed three times with water, followed by 0.1 N aqueous HCl, saturated aqueous $NaHCO_3$, and brine, dried over magnesium sulfate, and evaporated to leave 14.0 g of a pale orange oil. Distillation provided 11.9 g (65%) of the title compound: bp 78-82° (0.2 mm); n_D^{21} 1.5010; ir (neat) 3080, 3060, 2990, 2940, 1600, 1435, 1395, 1370, 1260, 1245, 1195, 1125, 1060, 1030, 815, 790, 740, 725, 705, 650 cm^{-1}; nmr ($CDCl_3$): 0.5 (3H, s), 1.3 (9H, s), 2.9 (2H, s) and 7.3-7.8 (5H, m).

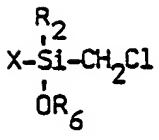
Example 18

Preparation of Chloromethyl(ethoxy)methyl(phenyl)silane

A solution of 18.2 ml (18.2 g, 0.10 mol) of chloromethyl(diethoxy)methylsilane in 200 ml of dry ether was stirred vigorously under N_2 and chilled while 56 ml (0.10 mol) of 1.8 molar phenyllithium in 70:30 cyclohexane-ether was added at a rate that held the mixture below -50°. The resulting slurry was allowed to warm to room temperature, treated cautiously with 10 ml of ethyl acetate, washed with water and brine, dried over magnesium sulfate, and evaporated to leave 16.8 g of a golden yellow liquid. Distillation provided 9.5 g (44%) of the title compound as a colorless liquid: bp 80-84° (0.1 mm); n_D^{20} 1.5144; nmr ($CDCl_3$) 0.5 (3H, s), 1.2 (3H, t, J = 7), 3.0 (2H, s), 3.8 (2H, q, J = 7), 7.2-7.8 (5H, m).

The compounds of Table V can be prepared using the procedures of Examples 16-18.

Table V



X = R_1, R_1'	R_2	R_6	
C_2H_5	CH_3	CH_3	
t-C_4H_9	CH_3	t-C_4H_9	
n-C_4H_9	CH_3	C_2H_5	
n-$C_{12}H_{25}$	C_2H_5	CH_3	
n-$C_{18}H_{37}$	n-C_6H_{13}	CH_3	
cyclopropyl	CH_3	s-C_4H_9	
cyclohexyl	CH_3	CH_3	
1-naphthyl	i-C_3H_7	i-C_3H_7	
2-naphthyl	cyclobutyl	n-C_3H_7	
phenyl	CH_3	H	
phenyl	CH_3	i-C_3H_7	bp 72-76°(0.1 mm)
phenyl	t-C_4H_9	H	
4-phenylphenyl	n-C_4H_9	CH_3	
4-phenylphenyl	t-C_4H_9	H	
4-phenylphenyl	CH_3	C_2H_5	
4-phenylphenyl	CH_3	n-C_4H_9	
4-chlorophenyl	n-C_4H_9	n-C_4H_9	
4-chlorophenyl	CH_3	CH_3	
4-chlorophenyl	CH_3	C_2H_5	
4-fluorophenyl	n-C_6H_{13}	n-C_3H_7	
4-fluorophenyl	CH_3	C_2H_5	
4-phenoxyphenyl	cyclohexyl	i-C_4H_9	
4-t-butylphenyl	n-C_3H_7	s-C_4H_9	
3-trifluoromethylphenyl	t-C_4H_9	H	
2-methylthiophenyl	cyclopentyl	C_2H_5	
2,4-dichlorophenyl	CH_3	CH_3	
2,4-dichlorophenyl	CH_3	C_2H_5	
2,4-dichlorophenyl	CH_3	t-C_4H_9	

Table V (continued)

$X = R_1, R_1'$	R_2	R_6
2,4-dichlorophenyl	n-C_4H_9	C_2H_5
2,3-dimethylphenyl	cyclopropyl	i-C_3H_7
2-methyl-5-fluorophenyl	s-C_4H_9	n-C_3H_7
2,6-dimethoxyphenyl	1,1-dimethylpropyl	H
3-methyl-4-chlorophenyl	C_2H_5	CH_3
3,5-dichlorophenyl	n-C_5H_{11}	C_2H_5
n-$C_{12}H_{25}$	2,4-dichlorophenyl	t-C_4H_9
n-$C_{18}H_{37}$	phenyl	CH_3
1-naphthyl	phenyl	C_2H_5
phenyl	phenyl	t-C_4H_9
4-fluorophenyl	phenyl	CH_3
4-chlorophenyl	phenyl	n-C_3H_7
4-phenylphenyl	phenyl	C_2H_5
4-phenylphenyl	phenyl	s-C_4H_9
4-t-butylphenyl	phenyl	s-C_4H_9
3-fluorophenyl	phenyl	C_2H_5
2-methoxyphenyl	phenyl	H
2-chlorophenyl	phenyl	CH_3
2,4-dichlorophenyl	phenyl	i-C_3H_7
3,5-dichlorophenyl	phenyl	n-C_3H_7
4-fluorophenyl	4-fluorophenyl	t-C_4H_9
4-fluorophenyl	4-fluorophenyl	C_2H_5
4-chlorophenyl	4-chlorophenyl	CH_3
4-chlorophenyl	4-chlorophenyl	C_2H_5
4-phenylphenyl	4-phenylphenyl	CH_3
2,4-dichlorophenyl	2,4-dichlorophenyl	C_2H_5
3-trifluoromethylphenyl	3-trifluoromethylphenyl	i-C_4H_9
2-methoxyphenyl	2-methoxyphenyl	H
2-chlorophenyl	4-fluorophenyl	H
3-trifluoromethylphenyl	4-t-butylphenyl	n-C_4H_9
2-fluoro-4-chlorophenyl	4-bromophenyl	i-C_3H_7
2,3-dimethylphenyl	4-methylthiophenyl	C_2H_5

Table V (continued)

$X = R_1, R_1'$	R_2	R_6
2,6-dimethoxyphenyl	4-methoxyphenyl	H
3,4-dichlorophenyl	4-methylphenyl	i-C_4H_9

Example 19

Preparation of (1,1'-Biphenyl-4-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane

A mixture of 2.6 g (0.010 mol) of (1,1'-biphenyl-4-yl)chloromethyldimethylsilane and 1.1 g (0.012 mol) of 1,2,4-triazole sodium salt in 5 ml of dimethylformamide was warmed to 80-90° for 2 hours, cooled, diluted with water, and extracted with ether. The ether solution was washed with water and brine, dried over magnesium sulfate, and evaporated to leave 2.3 g of colorless solid, m.p. 79-86°. Recrystallization from a mixture of 25 ml of hexanes and 2 ml of ethyl acetate gave 1.1 g (38%) of the title compound: m.p. 92-93°; ir (Nujol^{R}) 1255, 1130, 1000, 825, 760, 695 cm^{-1}; nmr ($CDCl_3$) 0.4 (6H, s), 3.9 (2H, s), 7.2-7.7 (9H, m), 7.8 (1H, s), 7.9 (1H, s); analysis for $C_{17}H_{19}N_3Si$ (mw 293.43):

Calculated C, 69.58; H, 6.53; N, 14.32;
Found C, 70.0; H, 6.6; N, 13.9;
69.8; 6.7; 13.8.

An equimolar mixture of 1,2,4-triazole and sodium methoxide can be used instead of preformed triazole sodium salt. Note that these reagents must be combined before the silane is added, since chloromethylsilanes react very vigorously with sodium methoxide in dimethylformamide, giving undesired products.

Example 20

Isolation of (1,1'-Biphenyl-4-yl)dimethyl(4H-1,2,4-triazol-4-ylmethyl)silane

A 5 g sample of once-crystallized 1,1'-(biphenyl-4-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane, prepared as in Example 14 using sodium methoxide-1,2,4-triazole, was subjected to high pressure liquid chromatography (Waters Prep PAK-500 silica gel cartridge, 250 ml per minute flow rate). Elution with ethyl acetate-hexane 50:50 removed first some minor impurities and then provided the pure 1H-1,2,4-triazol-1-ylmethyl compound, m.p. 99-100°. Continued elution with ethyl acetate-acetonitrile 80:20 provided a small amount of the title compound as a colorless solid: m.p. 130-133°C; nmr ($CDCl_3$) 0.4 (6H, s), 3.7 (2H, s), 7.2-7.7 (9H, m), 7.9 (2H, s); microanalysis for $C_{17}H_{19}N_3Si$ (mw 293.43):

Calculated:	C, 69.58;	H, 6.53;	N, 14.32.
Found:	C, 69.0;	H, 6.7;	N, 13.9.
	69.3;	6.7;	14.2.

Example 21

Preparation of Dimethyl(phenyl)(1H-1,2,4-triazol-1-ylmethyl)silane

A mixture of 9.0 ml (9.2 g, 0.050 mol) of chloromethyldimethylphenylsilane and 5.5 g (0.060 mol) of 1,2,4-triazole sodium salt in 25 ml of dimethylformamide was stirred and warmed to 90-95°C for 2 hours, cooled, diluted with water, and extracted with ether. The ether solution was washed with water and brine, dried over magnesium sulfate, and evaporated to leave 8.1 g (75%) of a pale brown oil, n_D^{22} 1.5350, containing the title compound and minor impurities as judged by nmr. A purer sample was obtained by distillation: bp 99° (0.02 mm); n_D^{20} 1.5403; nmr ($CDCl_3$) 0.4 (6H, s), 3.8 (2H, s), 7.2-7.7 (5H, m), 7.7 (1H, s), 7.8 (1H, s); analysis for $C_{11}H_{15}N_3Si$ (mw 217.34):

Calculated	C, 60.78;	H, 6.96;	N, 19.33;
Found	C, 60.7;	H, 7.0;	N, 16.9;
	60.2;	H, 7.0;	N, 16.8.

Example 22

Preparation of (4-Chlorophenyl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane

A mixture of 2.2 g (0.010 mol) of chloromethyl(4-chlorophenyl)dimethylsilane and 1.1 g (0.012 mol) of 1,2,4-triazole sodium salt in 5 ml of dimethylformamide was warmed to 80-90° for 2 hours, diluted with water, and extracted with ether. The ether solution was washed with water and brine, dried over magnesium sulfate, and evaporated to leave 2.1 g (83%) of the title compound as a yellow liquid: n_D^{21} 1.5428; ir (neat) 1555, 1470, 1245, 1130, 1080, 1010, 835, 805, 795, 735 cm^{-1}; nmr ($CDCl_3$) 0.4 (6H, s), 3.8 (2H, s), 7.4 (4H, broad s), 7.8 (1H, s), 7.9 (1H, s).

Example 23

Preparation of (2,4-Dichlorophenyl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane

A mixture of 5.1 g (0.020 mol) of chloromethyl-(2,4-dichlorophenyl)dimethylsilane and 2.0 g (0.022 mol) of 1,2,4-triazole sodium salt in 10 ml of dry dimethylformamide was stirred at 80-90° for 2 hours. The resulting slurry was cooled, diluted with water, and washed with ether. The ether extracts were washed with several portions of water and once with brine, dried over magnesium sulfate, and evaporated to leave 4.6 g (81%) of the title compound as a pale yellow liquid: n_D^{23} 1.5580; ir (neat) 1550, 1485, 1440, 1345, 1260, 1240, 1130, 1085, 1025, 1005, 835 cm^{-1}; nmr ($CDCl_3$) 0.5 (6H, s), 4.1 (2H, s), 7.2-7.5 (3H, m), 7.8 (1H, s), 7.9 (1H, s).

Example 24

Preparation of bis(4-Chlorophenyl)methyl(1H-1,2,4-triazol-1-ylmethyl)silane

A mixture of 6.3 g (0.020 mol) of chloromethyl-bis(4-chlorophenyl)methylsilane and 2.0 g (0.022 mol) of 1,2,4-triazole sodium salt in 10 ml of dry dimethylformamide was stirred at 80°C for 4 hours. The resulting slurry was cooled, diluted with water, and washed with ether. The ether extracts were washed with several portions of water and once with brine, dried over magnesium sulfate, and evaporated to leave 5.4 g of yellow oil. Kugelrohr distillation at 120-150° (airbath)/0.05 mm gave 4.0 g (58%) of the title compound as a pale yellow oil: n_D^{26} 1.5966; nmr ($CDCl_3$) 0.7 (3H, s), 4.1 (2H, s), 7.2-7.5 (8H, m), 7.8 (1H, s), 7.9 (1H, s).

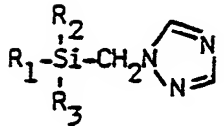
Example 25

Preparation of bis(4-Fluorophenyl)methyl(1H-1,2,4-triazol-1-ylmethyl)silane

A mixture of 4.2 g (0.015 mol) of (chloromethyl)-bis(4-fluorophenyl)methylsilane and 1.4 g (0.015 mol) of 1,2,4-triazole sodium salt in 8 ml of dimethylformamide was stirred at 80° for 2 hours. The resulting slurry was cooled, diluted with water, and worked up as in Example 24 to give 4.0 g of a pale yellow oil. Impurities were removed by Kugelrohr distillation at 120-125° (0.05 mm), leaving behind 2.3 g (49%) of the title compound as a yellow oil: n_D^{21} 1.5538; ir (neat) 3065, 3030, 2960, 2925, 1590, 1500, 1270, 1235, 1165, 1110, 1010, 830, 790 cm^{-1}; nmr ($CDCl_3$): 0.7 (3H, s), 4.2 (2H, s), 7.1 (4H, t, J = 9), 7.5 (4H, d of d, J = 6 and 9), 7.8 (1H, s) and 7.9 (1H, s).

By applying the procedures of Examples 19 and 21-25 to appropriate chloromethylsilanes, the compounds of Table VI in which Q_1=Q_2=H can be prepared.

Table VI



R_1	R_2	R_3	
C_2H_5	CH_3	CH_3	n_D^{22} 1.4713
i-C_3H_7	CH_3	CH_3	
n-C_4H_9	CH_3	CH_3	n_D^{19} 1.4687
t-C_4H_9	CH_3	CH_3	
n-$C_{12}H_{25}$	CH_3	CH_3	n_D^{23} 1.4626
n-$C_{14}H_{29}$	CH_3	CH_3	
n-$C_{18}H_{37}$	CH_3	CH_3	n_D^{21} 1.4597
cyclopropyl	CH_3	CH_3	
cyclobutyl	CH_3	CH_3	
cyclopentyl	CH_3	CH_3	
cyclohexyl	CH_3	CH_3	n_D^{22} 1.4906
1-naphthyl	CH_3	CH_3	n_D^{23} 1.6051
2-naphthyl	CH_3	CH_3	
4-bromophenyl	CH_3	CH_3	n_D^{20} 1.5647
4-fluorophenyl	CH_3	CH_3	bp 108° (0.2 mm)
4-methoxyphenyl	CH_3	CH_3	n_D^{26} 1.5401
4-phenoxyphenyl	CH_3	CH_3	n_D^{22} 1.5754
4-(4-chlorophenoxy)phenyl	CH_3	CH_3	n_D^{22} 1.5703
4-(4-fluorophenoxy)phenyl	CH_3	CH_3	
4-(4-trifluoromethylphenoxy)phenyl	CH_3	CH_3	
4-(4-methylphenoxy)phenyl	CH_3	CH_3	
4-thiomethylphenyl	CH_3	CH_3	n_D^{23} 1.5790
4-trifluoromethylphenyl	CH_3	CH_3	n_D^{22} 1.4909
4-methylphenyl	CH_3	CH_3	n_D^{21} 1.5350

Table VI (continued)

R_1	R_2	R_3	
4-methylsulfonylphenyl	CH_3	CH_3	n_D^{21} 1.5538
4-i-propylphenyl	CH_3	CH_3	
4-t-butylphenyl	CH_3	CH_3	n_D^{23} 1.5125
4-cyclohexylphenyl	CH_3	CH_3	n_D^{21} 1.5235
4-trifluoromethoxyphenyl	CH_3	CH_3	n_D^{22} 1.4768
4-(4-chlorophenyl)phenyl	CH_3	CH_3	
4-(4-bromophenyl)phenyl	CH_3	CH_3	n_D^{22} 1.5802
4-(4-methylphenyl)phenyl	CH_3	CH_3	
4-(4-trifluoromethylphenyl)phenyl	CH_3	CH_3	
4-(4-fluorophenyl)phenyl	CH_3	CH_3	
3-phenylphenyl	CH_3	CH_3	n_D^{21} 1.5939
3-trifluoromethylphenyl	CH_3	CH_3	n_D^{20} 1.4845
3-chlorophenyl	CH_3	CH_3	m.p. 37-43°
2-trifluoromethylphenyl	CH_3	CH_3	n_D^{23} 1.4964
2-phenylphenyl	CH_3	CH_3	n_D^{22} 1.5900
2-chlorophenyl	CH_3	CH_3	n_D^{22} 1.5442
2-methoxyphenyl	CH_3	CH_3	n_D^{21} 1.5216
2,3-dimethylphenyl	CH_3	CH_3	
2,3-dimethoxyphenyl	CH_3	CH_3	n_D^{22} 1.5322
2,4-difluorophenyl	CH_3	CH_3	
2-fluoro-4-chlorophenyl	CH_3	CH_3	
2-chloro-4-fluorophenyl	CH_3	CH_3	
2-chloro-4-phenylphenyl	CH_3	CH_3	
2-fluoro-4-phenylphenyl	CH_3	CH_3	
2-methyl-5-chlorophenyl	CH_3	CH_3	
2,6-dimethoxyphenyl	CH_3	CH_3	n_D^{23} 1.5404
2,6-dimethylphenyl	CH_3	CH_3	

Table VI (continued)

R_1	R_2	R_3	
3,4-dichlorophenyl	CH_3	CH_3	n_D^{22} 1.5602
3-methyl-4-fluorophenyl	CH_3	CH_3	
3,5-dichlorophenyl	CH_3	CH_3	m.p. 63-69°
C_2H_5	C_2H_5	CH_3	
i-C_3H_7	cyclohexyl	CH_3	
n-C_4H_9	n-C_4H_9	CH_3	n_D^{22} 1.4672
n-$C_{10}H_{21}$	cyclopropyl	CH_3	
n-$C_{12}H_{25}$	n-C_3H_7	CH_3	
n-$C_{14}H_{29}$	i-C_3H_7	CH_3	
n-$C_{18}H_{37}$	3-methylbutyl	CH_3	
cyclopropyl	n-C_6H_{13}	CH_3	
cyclopentyl	cylopentyl	CH_3	
cyclohexyl	cyclohexyl	CH_3	
1-naphthyl	n-C_4H_9	CH_3	
1-naphthyl	t-C_4H_9	CH_3	
2-naphthyl	n-C_5H_{11}	CH_3	
phenyl	n-C_3H_7	CH_3	
phenyl	n-C_4H_9	CH_3	n_D^{21} 1.5297
phenyl	1,1-dimethylpropyl	CH_3	
phenyl	n-C_6H_{13}	CH_3	
4-phenylphenyl	C_2H_5	CH_3	
4-phenylphenyl	n-C_4H_9	CH_3	n_D^{22} 1.5838
4-bromophenyl	i-C_3H_7	CH_3	
4-chlorophenyl	n-C_4H_9	CH_3	n_D^{21} 1.5344
4-fluorophenyl	n-C_4H_9	CH_3	n_D^{22} 1.5120
4-phenoxyphenyl	t-C_4H_9	CH_3	
4-i-propylphenyl	cyclopropyl	CH_3	
4-t-butylphenyl	i-C_4H_9	CH_3	
3-phenylphenyl	i-C_4H_9	CH_3	
3-trifluoromethylphenyl	s-C_4H_9	CH_3	

Table VI (continued)

R_1	R_2	R_3	
3-chlorophenyl	n-C_5H_{11}	CH_3	
2-methoxyphenyl	t-C_4H_9	CH_3	
2-thiomethylphenyl	cyclobutyl	CH_3	
2-phenylphenyl	i-C_4H_9	CH_3	
2,4-dichlorophenyl	n-C_4H_9	CH_3	n_D^{23} 1.5411
2,4-dichlorophenyl	cyclopropyl	CH_3	
2,3-dimethylphenyl	n-C_3H_7	CH_3	
2-methyl-5-fluorophenyl	cyclopentyl	CH_3	
2,5-dimethoxyphenyl	4-methylpentyl	CH_3	
2,6-dimethylphenyl	1-methylbutyl	CH_3	
3,4-dichlorophenyl	n-C_5H_{11}	CH_3	
3,5-dichlorophenyl	n-C_4H_9	CH_3	
3,5-dichlorophenyl	cyclohexyl	CH_3	
3-methyl-4-chlorophenyl	cyclopropyl	CH_3	
phenyl	phenyl	CH_3	n_D^{22} 1.5852
4-fluorophenyl	phenyl	CH_3	n_D^{20} 1.5718
4-chlorophenyl	phenyl	CH_3	n_D^{22} 1.5926
4-bromophenyl	phenyl	CH_3	n_D^{22} 1.6076
4-phenylphenyl	phenyl	CH_3	n_D^{21} 1.6328
4-t-butylphenyl	phenyl	CH_3	
4-thiomethylphenyl	phenyl	CH_3	
4-phenoxyphenyl	phenyl	CH_3	
4-trifluoromethoxyphenyl	phenyl	CH_3	
4-methylsulfonylphenyl	phenyl	CH_3	
4-cyclohexylphenyl	phenyl	CH_3	
4-(4-fluorophenyl)phenyl	phenyl	CH_3	
3-trifluoromethylphenyl	phenyl	CH_3	
2-chlorophenyl	phenyl	CH_3	n_D^{20} 1.5742
2-methoxyphenyl	phenyl	CH_3	

Table VI (continued)

R_1	R_2	R_3	
2,4-dichlorophenyl	phenyl	CH_3	n_D^{23} 1.5941
2-chloro-4-phenylphenyl	phenyl	CH_3	
2-fluoro-4-phenylphenyl	phenyl	CH_3	
3,5-dichlorophenyl	phenyl	CH_3	
2,5-dimethoxyphenyl	phenyl	CH_3	
2,6-dimethoxyphenyl	phenyl	CH_3	
4-bromophenyl	4-bromophenyl	CH_3	n_D^{21} 1.6245
4-phenylphenyl	4-phenylphenyl	CH_3	m.p. 42-46°
4-methoxyphenyl	4-methoxyphenyl	CH_3	n_D^{21} 1.5890
3-trifluoromethylphenyl	3-trifluoromethylphenyl	CH_3	
2-chlorophenyl	2-chlorophenyl	CH_3	n_D^{21} 1.5965
2-methoxyphenyl	2-methoxyphenyl	CH_3	
2,4-dichlorophenyl	2,4-dichlorophenyl	CH_3	n_D^{22} 1.6009
3,5-dichlorophenyl	3,5-dichlorophenyl	CH_3	
2-chlorophenyl	4-chlorophenyl	CH_3	n_D^{20} 1.5918
2-chlorophenyl	4-fluorophenyl	CH_3	
4-phenylphenyl	4-chlorophenyl	CH_3	
4-phenylphenyl	4-fluorophenyl	CH_3	
4-phenylphenyl	2,4-dichlorophenyl	CH_3	
4-fluorophenyl	2,4-dichlorophenyl	CH_3	
4-chlorophenyl	2,4-dichlorophenyl	CH_3	
1-naphthyl	2,6-dimethoxyphenyl	CH_3	
4-phenoxyphenyl	3,4-dichlorophenyl	CH_3	
C_2H_5	C_2H_5	C_2H_5	
i-C_3H_7	i-C_3H_7	i-C_3H_7	
n-C_4H_9	n-C_4H_9	n-C_4H_9	
n-C_8H_{17}	C_2H_5	cyclopentyl	
n-$C_{14}H_{29}$	cyclopropyl	1-methylbutyl	
n-$C_{18}H_{37}$	n-C_6H_{13}	n-C_6H_{13}	
cyclopropyl	C_2H_5	s-C_4H_9	

Table VI (continued)

R_1	R_2	R_3
cyclohexyl	n-C_3H_7	n-C_3H_7
1-naphthyl	n-C_4H_9	n-C_4H_9
2-naphthyl	n-C_4H_9	cyclobutyl
phenyl	cyclopropyl	n-C_6H_{13}
4-phenylphenyl	C_2H_5	C_2H_5
4-phenylphenyl	n-C_4H_9	n-C_4H_9
4-phenylphenyl	n-C_6H_{13}	n-C_6H_{13}
4-phenylphenyl	cyclohexyl	cyclohexyl
4-chlorophenyl	n-C_4H_9	n-C_4H_9
4-fluorophenyl	n-C_3H_7	n-C_3H_7
4-phenoxyphenyl	n-C_4H_9	cyclohexyl
4-(4-chlorophenoxy)phenyl	n-C_4H_9	n-C_4H_9
4-t-butylphenyl	s-C_4H_9	i-C_4H_9
3-methoxyphenyl	C_2H_5	t-C_4H_9
3-trifluoromethylphenyl	s-C_4H_9	s-C_4H_9
2-thiomethylphenyl	i-C_3H_7	3-methylbutyl
2-phenylphenyl	cyclohexyl	cyclohexyl
2,4-dichlorophenyl	n-C_4H_9	n-C_4H_9
2,6-dimethylphenyl	t-C_4H_9	t-C_4H_9
3,5-dichlorophenyl	cyclopentyl	cyclopentyl
3-methyl-4-chlorophenyl	s-C_4H_9	s-C_4H_9
2-methyl-5-fluorophenyl	n-C_4H_9	i-C_4H_9
C_2H_5	phenyl	phenyl
cyclohexyl	phenyl	phenyl
n-$C_{18}H_{37}$	phenyl	phenyl
n-C_4H_9	4-chlorophenyl	4-chlorophenyl
n-$C_{12}H_{25}$	4-chlorophenyl	4-chlorophenyl
1-naphthyl	4-fluorophenyl	4-fluorophenyl
cyclopropyl	phenyl	4-t-butylphenyl
n-C_4H_9	phenyl	4-phenylphenyl
t-C_4H_9	phenyl	2,4-dichlorophenyl
n-C_3H_7	phenyl	3-trifluoromethylphenyl

Table VI (continued)

R_1	R_2	R_3
i-C_4H_9	phenyl	3,5-dichlorophenyl
cyclopentyl	phenyl	2,6-dimethoxyphenyl
n-$C_{14}H_{29}$	4-chlorophenyl	2-fluorophenyl
n-C_4H_9	4-fluorophenyl	4-phenylphenyl
phenyl	phenyl	phenyl m.p. 118-121°
4-chlorophenyl	4-chlorophenyl	4-chlorophenyl
4-fluorophenyl	4-fluorophenyl	4-fluorophenyl
4-phenylphenyl	4-phenylphenyl	4-phenylphenyl
2,4-dichlorophenyl	2,4-dichlorophenyl	2,4-dichlorophenyl
phenyl	4-fluorophenyl	4-fluorophenyl
phenyl	4-chlorophenyl	4-chlorophenyl
phenyl	4-phenylphenyl	4-phenylphenyl
phenyl	2,4-dichlorophenyl	2,4-dichlorophenyl
2-naphthyl	4-methylthiophenyl	4-methylthiophenyl
4-chlorophenyl	2-methoxyphenyl	2-methoxyphenyl
4-chlorophenyl	3-chlorophenyl	3-chlorophenyl
phenyl	2-chlorophenyl	4-fluorophenyl
phenyl	4-chlorophenyl	4-phenylphenyl
1-naphthyl	4-bromophenyl	3-methylphenyl
4-phenoxyphenyl	3,5-dimethylphenyl	3,4-dichlorophenyl

Example 26

Preparation of (3,5-Dimethyl-1H-1,2,4-triazol-1-ylmethyl)[bis(4-fluorophenyl)]methylsilane

The title compound is prepared by applying the procedure of Example 25 to equimolar quantities of chloromethyl[bis(4-fluorophenyl)]methylsilane and 3,5-dimethyl-1,2,4-triazole sodium salt.

Related compounds may be made by substituting salts of 3-methyl-1,2,4-triazole for the 3,5-dimethyl-triazole salt.

Example 27

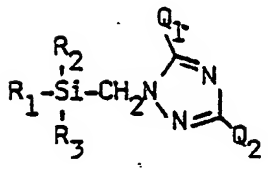
Preparation of (1,1'-Biphenyl-4-yl)dimethyl(3-methyl-1H-1,2,4-triazol-1-ylmethyl)silane

A solution of 5.9 g (0.020 mol) of (1,1'-biphenyl-4-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane in 40 ml of dry tetrahydrofuran was chilled to -40° under N_2 and stirred while 12.5 ml (0.020 mol) of 1.6 molar n-butyllithium in hexane was added dropwise. The resulting yellow solution was stirred another 15 minutes at -40°, treated with 1.9 ml (4.2 g, 0.030 mol) of methyl iodide, and allowed to warm to room temperature. The resulting solution was diluted with water and extracted with hexanes. Washing the organic extracts with water and brine, drying over magnesium sulfate, and evaporation gave 5.7 g of solid, which was purified by dry-column chromatography over silica gel (ethyl acetate elution) to give 1.1 g of crude product. Recrystallization from 12 ml of 3:1 hexanes-ethyl acetate then gave 0.97 g (16%) of the title compound as an off white solid: m.p. 95-98°; ir (Nujol^R) 1590, 1270, 1250, 1180, 1120, 830, 765, 700 cm^{-1}; nmr ($CDCl_3$) 0.5 (6H, s), 2.2 (3H, s), 3.7 (2H, s), 7.2-7.7 (9H, m), 7.8 (1H, s).

Although the indicated structure is preferred for steric reasons, the position of the methyl group on the triazole ring has not been proven, and it is possible that the product is (1,1'-biphenyl-4-yl)-dimethyl(5-methyl-1H-1,2,4-triazol-1-ylmethyl)silane.

The procedures of Examples 26 and 27 may be used to prepare the compounds of Table VII.

Table VII



R_1	R_2	R_3	Q_1	Q_2
C_2H_5	CH_3	CH_3	CH_3	CH_3
n-$C_{18}H_{37}$	CH_3	CH_3	H	CH_3
cyclohexyl	CH_3	CH_3	CH_3	CH_3
1-naphthyl	CH_3	CH_3	CH_3	CH_3
phenyl	CH_3	CH_3	H	CH_3
phenyl	CH_3	CH_3	CH_3	H
4-phenylphenyl	CH_3	CH_3	CH_3	CH_3
4-(4-fluorophenyl)phenyl	CH_3	CH_3	CH_3	CH_3
4-phenoxyphenyl	CH_3	CH_3	CH_3	CH_3
3-trifluoromethylphenyl	CH_3	CH_3	CH_3	CH_3
2-methoxyphenyl	CH_3	CH_3	CH_3	CH_3
2,4-dichlorophenyl	CH_3	CH_3	CH_3	CH_3
2-chloro-4-phenylphenyl	CH_3	CH_3	CH_3	CH_3
phenyl	n-C_4H_9	CH_3	CH_3	CH_3
4-phenylphenyl	n-C_4H_9	CH_3	H	CH_3
2,4-dichlorophenyl	n-C_6H_{13}	CH_3	CH_3	CH_3
4-(4-chlorophenoxy)phenyl	cyclohexyl	CH_3	CH_3	CH_3
phenyl	phenyl	CH_3	H	CH_3
4-fluorophenyl	phenyl	CH_3	CH_3	CH_3
4-fluorophenyl	phenyl	CH_3	H	CH_3
4-chlorophenyl	phenyl	CH_3	H	CH_3
4-fluorophenyl	4-fluorophenyl	CH_3	H	CH_3
4-fluorophenyl	4-fluorophenyl	CH_3	CH_3	H
4-chlorophenyl	4-chlorophenyl	CH_3	H	CH_3
4-chlorophenyl	4-chlorophenyl	CH_3	CH_3	CH_3
2-chlorophenyl	4-chlorophenyl	CH_3	H	CH_3

Table VII (continued)

R_1	R_2	R_3	Q_1	Q_2
2,4-dichlorophenyl	2,4-dichlorophenyl	CH_3	CH_3	CH_3
n-$C_{18}H_{37}$	n-C_6H_{13}	n-C_6H_{13}	CH_3	CH_3
1-naphthyl	n-C_4H_9	n-C_4H_9	H	CH_3
phenyl	phenyl	phenyl	H	CH_3
phenyl	phenyl	phenyl	CH_3	H
phenyl	phenyl	phenyl	CH_3	CH_3

Example 28

Preparation of the 1:1 complex of (1,1'-Biphenyl-4-yl)-dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane and Cuprous Chloride

A mixture of 5.0 g (0.017 mol) of (1,1'-biphenyl-4-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane and 1.7 g (0.017 mol) of cuprous chloride in 170 ml of tetrahydrofuran was refluxed under N_2 for 30 minutes, and the resulting deep green solution was evaporated to leave the title compound as a dark greenish-brown solid: m.p. 85-90°; ir (Nujol^R) 3110, 1590, 1280, 1250, 1120, 1010, 990, 840, 825, 760, 700 cm^{-1}.

The following metal complexes of (1,1'-biphenyl-4-yl)dimethyl(1H-1,2,4-triazol-4-ylmethyl)silane were prepared similarly:

1:1 Complex with cupric chloride: m.p. 83-87°

2:1 Complex with cupric chloride: m.p. 85-92°

1:1 Complex with zinc chloride: n_D^{21} 1.5737

1:1 Complex with manganous sulfate: m.p. 244-250° (decomp.)

Example 29

Preparation of the 4-Dodecylbenzenesulfonate Salt of (1,1'-Biphenyl-4-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane

A solution of 1.0 g (0.0034 mol) of (1,1'-biphenyl-4-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)-silane in 10 ml of dichloromethane was combined with a solution of 1.1 g (0.0034 mol) of 4-dodecylbenzenesulfonic acid in 10 ml of dichloromethane. The resulting solution was evaporated to leave the title salt as a viscous yellow oil: n_D^{20} 1.5645; ir (neat) 3110, 3050, 3020, 2960, 2920, 2850, 2570, 1920, 1600, 1545, 1485, 1455, 1405, 1250, 1225, 1165, 1120, 1030, 1010, 990, 845, 825, 755, 735, 700, 670, 635 cm^{-1}.

Example 30

Preparation of the 2:1 complex of [bis(4-Fluorophenyl)]methyl(1H-1,2,4-triazol-1-ylmethyl)silane and Cupric Chloride

A mixture of 1.0 g (0.0032 mol) of [bis(4-fluorophenyl)]methyl(1H-1,2,4-triazol-1-ylmethyl)silane and 0.2 g (0.0016 mol) of cupric chloride in 30 ml of tetrahydrofuran was refluxed under N_2 for 30 minutes and evaporated to leave the title complex as a blue-green glass: no distinct m.p.; ir (Nujol^R) 1580, 1490, 1230, 1160, 1110, 830, 785 cm^{-1}.

The 1:1 complex with cuprous chloride was prepared similarly to give a dark green glass: no distinct m.p.; ir as above.

By applying the procedures of Examples 26-28, any of the compounds of Tables VI, VII, VIII, IX, XII and XIII can be converted to salts or metal complexes.

Example 31

Preparation of (1,1-'Biphenyl-4-yl)(1H-1,2,4-triazol-1-ylmethyl)(methoxy)methylsilane

A mixture of (1,1'-biphenyl-4-yl)chlorochloromethylmethylsilane and two equivalents of 1,2,4-triazole sodium salt in dimethylformamide is warmed to 80-90°C for 2 hours. Ten equivalents of methanol is then added, and the mixture is held at 70°C for 1 hour, cooled, diluted with water, and quickly extracted with ether. Washing the ether solution with water and brine, drying over magnesium sulfate, and evaporation leaves the title compound.

Related compounds can be made in the same way, using the appropriate chlorosilane and alcohol; for R_6 = OH, water is used instead of an alcohol, and hydrolysis is conducted at 20-25°C instead of 70°.

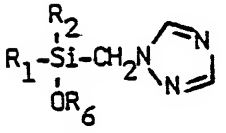
Example 32

Preparation of (1,1-dimethylethoxy)methyl(phenyl)(1H-1,2,4-triazol-1-ylmethyl)silane

A mixture of 3.6 g (0.015 mol) of chloromethyl-(1,1-dimethylethoxy)methyl(phenyl)silane and 1.3 g (0.015 mol) of 1,2,4-triazole sodium salt in 8 ml of dimethylformamide was stirred at 80° for 2 hours, cooled, and poured onto water. The resulting mixture was extracted with ether, and the ether extracts were washed with water and brine, dried over magnesium sulfate, and evaporated to leave 2.7 g of a yellow oil. Chromatography on silica gel, eluting with 50:50 ethyl acetate-hexanes, provided 1.5 g (36%) of the title compound as a pale yellow oil: n_D^{21} 1.5134; ir (neat) 3120, 3070, 3045, 2975, 2925, 1500, 1425, 1380, 1365, 1270, 1255, 1240, 1190, 1140, 1115, 1050, 1020, 1010, 830, 810, 790, 740, 700, 680 cm^{-1}; nmr ($CDCl_3$): 0.6 (3H, s), 1.3 (9H, s), 3.9 (2H, s), 7.3-7.7 (5H, m), 7.9 (1H, s) and 8.0 (1H, s).

The compounds of Table VIII and IX in which $Q_1=Q_2=H$ can be made using the procedures of Examples 31 and 32.

Table VIII



R_1	R_2	R_6	
C_2H_5	CH_3	CH_3	
t-C_4H_9	CH_3	t-C_4H_9	
n-C_4H_9	CH_3	C_2H_5	
n-$C_{12}H_{25}$	C_2H_5	CH_3	
n-$C_{18}H_{37}$	n-C_6H_{13}	CH_3	
cyclopropyl	CH_3	s-C_4H_9	
cyclohexyl	CH_3	CH_3	
1-naphthyl	i-C_3H_7	i-C_3H_7	
2-naphthyl	cyclobutyl	n-C_3H_7	
phenyl	CH_3	H	
phenyl	CH_3	CH_3	
phenyl	CH_3	C_2H_5	
phenyl	CH_3	i-C_3H_7	n_D^{20} 1.5367
phenyl	t-C_4H_9	H	
4-phenylphenyl	n-C_4H_9	CH_3	
4-phenylphenyl	t-C_4H_9	H	
4-phenylphenyl	CH_3	C_2H_5	
4-phenylphenyl	CH_3	n-C_4H_9	
4-chlorophenyl	n-C_4H_9	n-C_4H_9	
4-chlorophenyl	CH_3	CH_3	
4-chlorophenyl	CH_3	C_2H_5	
4-fluorophenyl	n-C_6H_{13}	n-C_3H_7	
4-fluorophenyl	CH_3	C_2H_5	
4-phenoxyphenyl	cyclohexyl	i-C_4H_9	
4-t-butylphenyl	n-C_3H_7	s-C_4H_9	
3-trifluoromethylphenyl	t-C_4H_9	H	
2-methylthiophenyl	cyclopentyl	C_2H_5	

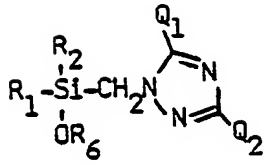
Table VIII (continued)

R_1	R_2	R_6
2,4-dichlorophenyl	CH_3	CH_3
2,4-dichlorophenyl	CH_3	C_2H_5
2,4-dichlorophenyl	CH_3	t-C_4H_9
2,4-dichlorophenyl	n-C_4H_9	C_2H_5
2,3-dimethylphenyl	cyclopropyl	i-C_3H_7
2-methyl-5-fluorophenyl	s-C_4H_9	n-C_3H_7
2,6-dimethoxyphenyl	1,1-dimethylpropyl	H
3-methyl-4-chlorophenyl	C_2H_5	CH_3
3,5-dichlorophenyl	n-C_5H_{11}	C_2H_5
n-$C_{12}H_{25}$	2,4-dichlorophenyl	t-C_4H_9
n-$C_{18}H_{37}$	phenyl	CH_3
1-naphthyl	phenyl	C_2H_5
phenyl	phenyl	t-C_4H_9
4-fluorophenyl	phenyl	CH_3
4-chlorophenyl	phenyl	n-C_3H_7
4-phenylphenyl	phenyl	C_2H_5
4-phenylphenyl	phenyl	s-C_4H_9
4-t-butylphenyl	phenyl	s-C_4H_9
3-fluorophenyl	phenyl	C_2H_5
2-methoxyphenyl	phenyl	H
2-chlorophenyl	phenyl	CH_3
2,4-dichlorophenyl	phenyl	i-C_3H_7
3,5-dichlorophenyl	phenyl	n-C_3H_7
4-fluorophenyl	4-fluorophenyl	t-C_4H_9
4-fluorophenyl	4-fluorophenyl	C_2H_5
4-chlorophenyl	4-chlorophenyl	CH_3
4-chlorophenyl	4-chlorophenyl	C_2H_5
4-phenylphenyl	4-phenylphenyl	CH_3
2,4-dichlorophenyl	2,4-dichlorophenyl	C_2H_5
3-trifluoromethylphenyl	3-trifluoromethylphenyl	i-C_4H_9
2-methoxyphenyl	2-methoxyphenyl	H
2-chlorophenyl	4-fluorophenyl	

Table VIII (continued)

R_1	R_2	R_6
3-trifluoromethylphenyl	4-t-butylphenyl	n-C_4H_9
2-fluoro-4-chlorophenyl	4-bromophenyl	i-C_3H_7
2,3-dimethylphenyl	4-methylthiophenyl	C_2H_5
2,6-dimethoxyphenyl	4-methoxyphenyl	H
3,4-dichlorophenyl	4-methylphenyl	i-C_4H_9

Table IX



R_1	R_2	R_6	Q_1	Q_2
C_2H_5	CH_3	CH_3	CH_3	CH_3
cyclohexyl	CH_3	$\underline{i}$-C_3H_7	H	CH_3
$\underline{n}$-$C_{18}H_{37}$	$\underline{n}$-C_6H_{13}	$\underline{t}$-C_4H_9	CH_3	CH_3
1-naphthyl	CH_3	$\underline{i}$-C_3H_7	CH_3	CH_3
phenyl	CH_3	$\underline{t}$-C_4H_9	H	CH_3
phenyl	CH_3	$\underline{t}$-C_4H_9	CH_3	H
phenyl	CH_3	$\underline{t}$-C_4H_9	CH_3	CH_3
phenyl	CH_3	$\underline{s}$-C_4H_9	H	CH_3
phenyl	CH_3	$\underline{i}$-C_4H_9	H	CH_3
4-phenylphenyl	$\underline{n}$-C_4H_9	$\underline{t}$-C_4H_9	H	CH_3
4-phenylphenyl	CH_3	$\underline{t}$-C_4H_9	H	CH_3
4-phenylphenyl	CH_3	$\underline{t}$-C_4H_9	CH_3	CH_3
4-chlorophenyl	CH_3	$\underline{t}$-C_4H_9	H	CH_3
4-chlorophenyl	CH_3	$\underline{t}$-C_4H_9	CH_3	CH_3
4-fluorophenyl	CH_3	$\underline{t}$-C_4H_9	H	CH_3
4-fluorophenyl	CH_3	$\underline{t}$-C_4H_9	CH_3	CH_3
phenyl	phenyl	C_2H_5	CH_3	CH_3
phenyl	phenyl	$\underline{n}$-C_3H_7	CH_3	CH_3
4-fluorophenyl	phenyl	$\underline{i}$-C_3H_7	H	CH_3
4-fluorophenyl	phenyl	$\underline{t}$-C_4H_9	CH_3	CH_3
4-chlorophenyl	phenyl	$\underline{i}$-C_3H_7	H	CH_3
2,4-dichlorophenyl	phenyl	H	CH_3	CH_3
4-fluorophenyl	4-fluorophenyl	$\underline{t}$-C_4H_9	H	CH_3
4-fluorophenyl	4-fluorophenyl	$\underline{t}$-C_4H_9	CH_3	H
4-fluorophenyl	4-fluorophenyl	$\underline{t}$-C_4H_9	CH_3	CH_3
2-methoxyphenyl	2-methoxyphenyl	C_2H_5	CH_3	CH_3
3-methylphenyl	3-methylphenyl	$\underline{i}$-C_4H_9	H	CH_3

Example 33

Preparation of Chloromethyl(dichloro)phenylsilane

A solution of 25.1 ml (36.8 g, 0.200 mol) of chloromethyltrichlorosilane in 400 ml dry tetrahydrofuran was cooled to -78° under nitrogen and stirred vigorously while 48.0 ml (0.100 mol) of 2.1 molar phenyllithium was slowly dripped in over 1 hour. After stirring another 30 minutes at -78° the solution was allowed to warm to room temperature and evaporated to about 200 ml. Addition of 500 ml ether, filtration to remove precipitated lithium chloride, and evaporation of the filtrate left 25.0 g of liquid. Distillation gave 6.5 g (29%) of the title compound as a colorless liquid: bp 62-82° (0.15 mm); nmr ($CDCl_3$): δ 3.3 (s, 2) and 7.1-7.9 (m, 5).

Example 34

Preparation of Chloromethyl(diethoxy)phenylsilane

A solution of 1.0 g (0.0044 mol) of chloromethyl(dichloro)phenylsilane in 8 ml of absolute ethanol was cooled to 0° under nitrogen and stirred while 0.61 ml (0.445 g, 0.0044 mol) of triethylamine was slowly added, giving a slurry that was allowed to warm to room temperature. Addition of 50 ml of ether, filtration to remove precipitated triethylamine/hydrochloride, and evaporation of the filtrate left a residue which was filtered through a short silica gel column (95% petroleum ether:ethyl acetate as the eluent) to give 0.80 (73%) of the title compound as a colorless oil: nmr ($CDCl_3$): 1.25 (t, 6, J = 6Hz), 3.0 (s, 2), 3.9 (q, 4, J = 6Hz) and 7.2-7.9 (m, 5).

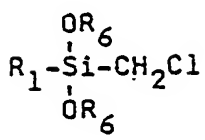
Example 35

Preparation of Chloromethyl(phenyl)bis(2-propoxy)silane

A solution of 2.0 g (0.009 mol) of chloromethyl-(dichloro)phenylsilane and 5 ml of 2-propanol in 15 ml of dimethylformamide was stirred under N_2 while 2.5 ml (1.9 g, 0.018 mol) of triethylamine was added dropwise. The resulting slurry was warmed to 80° for 2 hours, cooled, diluted with water, and extracted with ether. The ether extracts were washed with water and brine, dried over magnesium sulfate, and evaporated to leave 2.2 g of liquid. Column chromatography over silica gel, eluting with petroleum ether, provided 1.4 g (58%) of the title compound as a colorless liquid: n_D^{22} 1.4741; nmr ($CDCl_3$) 1.2 (12H, d, J = 6), 3.0 (2H, s), 4.3 (2H, septet, J = 6), 7.3-7.8 (5H, m).

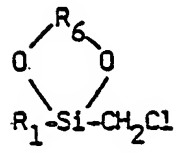
The compounds of Tables X and XI can be made using the procedures of Examples 33-35.

Table X



R_1	R_6
C_2H_5	$\underline{t}$-C_4H_9
$\underline{n}$-C_4H_9	C_2H_5
$\underline{n}$-$C_{18}H_{37}$	CH_3
cyclohexyl	$\underline{n}$-C_3H_7
1-naphthyl	$\underline{i}$-C_4H_9
phenyl	CH_3
phenyl	$\underline{n}$-C_3H_7
phenyl	$\underline{t}$-C_4H_9
4-phenylphenyl	C_2H_5
4-phenylphenyl	$\underline{n}$-C_4H_9
4-fluorophenyl	CH_3
4-fluorophenyl	C_2H_5
4-chlorophenyl	C_2H_5
4-chlorophenyl	$\underline{i}$-C_3H_7
3-trifluoromethylphenyl	$\underline{s}$-C_4H_9
2-methoxyphenyl	$\underline{n}$-C_3H_7
2,3-dimethylphenyl	$\underline{i}$-C_4H_9
2,4-dichlorophenyl	CH_3
2,4-dichlorophenyl	C_2H_5
2-methoxy-5-fluorophenyl	$\underline{i}$-C_3H_7
2,6-dimethoxyphenyl	CH_3
3,4-dichlorophenyl	C_2H_5
3,5-dichlorophenyl	$\underline{n}$-C_4H_9

Table XI



R_1	R_6	
C_2H_5	$-CH_2CH_2-$	
	$-CH_2\underset{\displaystyle CH_3}{\underset{\vert}{C}}H-$	
$n-C_4H_9$	$-CH_2CH_2CH_2-$	
$n-C_{18}H_{37}$	$-CH_2\underset{\displaystyle C_2H_5}{\underset{\vert}{C}}H-$	
cyclohexyl	$-CH_2CH_2-$	
1-naphthyl	$-CH_2CH_2-$	
phenyl	$-CH_2\underset{\displaystyle C_2H_5}{\underset{\vert}{C}}H-$	
phenyl	$-CH_2\underset{\displaystyle n-C_3H_7}{\underset{\vert}{C}}H-$	
phenyl	$-C(CH_3)_2C(CH_3)_2-$	bp 142-162°(10mm)
4-phenylphenyl	$-CH_2CH_2-$	
4-phenylphenyl	$-CH_2\underset{\displaystyle C_2H_5}{\underset{\vert}{C}}H-$	
4-phenylphenyl	$-\underset{\displaystyle CH_3}{\underset{\vert}{C}}H-\underset{\displaystyle CH_3}{\underset{\vert}{C}}H-$	
4-fluorophenyl	$-CH_2CH_2-$	
4-fluorophenyl	$-CH_2\underset{\displaystyle CH_3}{\underset{\vert}{C}}H-$	
4-chlorophenyl	$-CH_2\underset{\displaystyle C_2H_5}{\underset{\vert}{C}}H-$	
4-chlorophenyl	$-C(CH_3)_2C(CH_3)_2-$	
3-trifluoromethylphenyl	$-\underset{\displaystyle CH_3}{\underset{\vert}{C}}HCH_2C(CH_3)_2$	

Table XI (continued)

	R_1	R_6	
		$-CH_2\underset{\underset{n\text{-}C_4H_9}{|}}{CH}-$	
	2-methoxyphenyl	$-CH_2CH_2-$	
	2,3-dimethylphenyl	$-CH_2\underset{\underset{C_2H_5}{|}}{CH}-$	
	2,4-dichlorophenyl	$-CH_2\underset{\underset{n\text{-}C_3H_7}{|}}{CH}-$	
	2,4-dichlorophenyl	$-\underset{\underset{CH_3}{|}}{CH}C(CH_3)_2\underset{\underset{CH_3}{|}}{CH}-$	
	2-methoxy-5-fluorophenyl	$-CH_2CH_2-$	
	2,6-dimethoxyphenyl	$-\underset{\underset{CH_3}{|}}{CH}CH_2\underset{\underset{CH_3}{|}}{CH}-$	
	3,4-dichlorophenyl	$-\underset{\underset{CH_3}{|}}{CH}-\underset{\underset{CH_3}{|}}{CH}-$	
	3,5-dichlorophenyl	$-CH_2CH=CHCH_2-$	
	C_2H_5	$-\underset{\underset{CH_3}{|}}{CH}CH_2CH_2\underset{\underset{CH_3}{|}}{CH}-$	
	$n\text{-}C_{18}H_{37}$	$-CH_2CH=CHCH_2-$	
	phenyl	$-C(CH_3)_2CH=CHC(CH_3)_2-$	
	phenyl	$-\underset{\underset{CH_3}{|}}{CH}CH_2CH_2\underset{\underset{CH_3}{|}}{CH}-$	bp 57-60° (0.15 mm)
	phenyl	$-C(CH_3)_2CH_2CH_2C(CH_3)_2-$	
	4-phenylphenyl	$-CH_2CH=CHCH_2-$	
	4-phenylphenyl	$-CH_2\underset{\underset{CH_3}{|}}{C}=\underset{\underset{CH_3}{|}}{C}CH_2-$	
	4-fluorophenyl	$-CH_2-CH=CHCH_2-$	
	4-chlorophenyl	$-CH_2CH_2CH_2CH_2-$	
	4-phenoxyphenyl	$-CH_2CH_2CH_2\underset{\underset{n\text{-}C_4H_9}{|}}{CH}-$	
	3-trifluoromethylphenyl	$-\underset{\underset{CH_3}{|}}{CH}CH=\underset{\underset{CH_3}{|}}{CH}-$	
	2-methoxyphenyl	$-CH_2\underset{\underset{CH_3}{|}}{CH}-\underset{\underset{CH_3}{|}}{CH}CH_2-$	

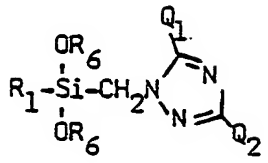
Example 36

Preparation of Phenylbis(2-propoxy)(1H-1,2,4-triazol-1-ylmethyl)silane

The title compound can be made by applying the procedure of Example 32 to chloromethyl(phenyl)bis-(2-propoxy)silane: n_D^{22} 1.4962; nmr ($CDCl_3$) 1.1 (12H, d, J = 6), 4.0 (2H, s), 4.3 (2H, septet, J = 6), 7.2-8.0 (7H, m).

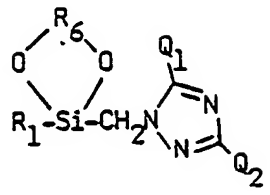
The compounds of Tables XII and XIII can be made similarly.

Table XII



R_1	R_6	Q_1	Q_2
C_2H_5	$\underline{t}$-C_4H_9	H	H
$\underline{n}$-C_4H_9	C_2H_5	H	H
$\underline{n}$-$C_{18}H_{37}$	CH_3	H	H
cyclohexyl	$\underline{n}$-C_3H_7	H	H
1-naphthyl	$\underline{i}$-C_4H_9	H	H
phenyl	CH_3	CH_3	CH_3
phenyl	$\underline{n}$-C_3H_7	H	CH_3
phenyl	$\underline{i}$-C_3H_7	CH_3	CH_3
phenyl	$\underline{t}$-C_4H_9	H	H
4-phenylphenyl	C_2H_5	CH_3	CH_3
4-phenylphenyl	$\underline{n}$-C_4H_9	H	H
4-fluorophenyl	CH_3	H	H
4-fluorophenyl	C_2H_5	H	H
4-chlorophenyl	C_2H_5	H	H
4-chlorophenyl	$\underline{i}$-C_3H_7	H	H
3-trifluoromethylphenyl	$\underline{s}$-C_4H_9	CH_3	CH_3
2-methoxyphenyl	$\underline{n}$-C_3H_7	H	CH_3
2,3-dimethylphenyl	$\underline{i}$-C_4H_9	CH_3	CH_3
2,4-dichlorophenyl	CH_3	H	H
2,4-dichlorophenyl	C_2H_5	H	H
2-methoxy-5-fluorophenyl	$\underline{i}$-C_3H_7	H	H
2,6-dimethoxyphenyl	CH_3	H	H
3,4-dichlorophenyl	C_2H_5	H	H
3,5-dichlorophenyl	$\underline{n}$-C_4H_9	H	H

Table XIII



R_1	R_6	Q_1	Q_2
C_2H_5	$-CH_2CH_2-$	CH_3	CH_3
	$-CH_2\overset{CH_3}{\overset{\vert}{C}}H-$		
$n-C_4H_9$	$-CH_2CH-$	H	CH_3
$n-C_{18}H_{37}$	$-CH_2CH_2CH_2-$	H	H
	$-CH_2\overset{C_2H_5}{\overset{\vert}{C}}H-$		
cyclohexyl	$-CH_2CH-$	H	CH_3
1-naphthyl	$-CH_2CH_2-$	CH_3	H
phenyl	$-CH_2CH_2-$	CH_3	CH_3
	$-CH_2\overset{C_2H_5}{\overset{\vert}{C}}H-$		
phenyl	$-CH_2CH-$	H	H
	$-CH_2\overset{n-C_3H_7}{\overset{\vert}{C}}H-$		
phenyl	$-CH_2CH-$	H	H
phenyl	$-C(CH_3)_2C(CH_3)_2-$	H	H
4-phenylphenyl	$-CH_2CH_2-$	H	H
	$-CH_2\overset{C_2H_5}{\overset{\vert}{C}}H-$		
4-phenylphenyl	$-CH_2CH-$	H	H
	$-\overset{CH_3}{\overset{\vert}{C}}H-\overset{CH_3}{\overset{\vert}{C}}H-$		
4-fluorophenyl	$-CH_2CH_2-$	H	H
	$-CH_2\overset{CH_3}{\overset{\vert}{C}}H-$		
4-fluorophenyl	$-CH_2CH-$	H	H
	$-CH_2\overset{C_2H_5}{\overset{\vert}{C}}H-$		
4-chlorophenyl	$-CH_2CH-$	H	H
4-chlorophenyl	$-C(CH_3)_2C(CH_3)_2-$	H	H
	$-\overset{CH_3}{\overset{\vert}{C}}HCH_2C(CH_3)_2-$		
3-trifluoromethylphenyl		CH_3	C

Table XIII (continued)

R_1	R_6	Q_1	Q_2
2-methoxyphenyl	$-CH_2\underset{\underset{n\text{-}C_4H_9}{|}}{C}H-$	H	CH_3
2,3-dimethylphenyl	$-CH_2CH_2-$	CH_3	CH_3
2,4-dichlorophenyl	$-CH_2\underset{\underset{C_2H_5}{|}}{C}H-$	H	H
2,4-dichlorophenyl	$-CH_2\underset{\underset{n\text{-}C_3H_7}{|}}{C}H-$	H	H
2-methoxy-5-fluorophenyl	$-\underset{\underset{CH_3}{|}}{C}HC(CH_3)_2\underset{\underset{CH_3}{|}}{C}H-$	H	H
2,6-dimethoxyphenyl	$-CH_2CH_2-$	H	H
3,4-dichlorophenyl	$-\underset{\underset{CH_3}{|}}{C}HCH_2\underset{\underset{CH_3}{|}}{C}H-$	H	H
3,5-dichlorophenyl	$-\underset{\underset{CH_3}{|}}{C}H-\underset{\underset{CH_3}{|}}{C}H-$	H	H
C_2H_5	$-CH_2CH=CHCH_2-$	CH_3	CH_3
$n\text{-}C_{18}H_{37}$	$-\underset{\underset{CH_3}{|}}{C}HCH_2CH_2\underset{\underset{CH_3}{|}}{C}H-$	H	CH_3
phenyl	$-CH_2CH=CHCH_2-$	H	H
phenyl	$-C(CH_3)_2CH=CHC(CH_3)_2-$	H	H
phenyl	$-\underset{\underset{CH_3}{|}}{C}HCH_2CH_2\underset{\underset{CH_3}{|}}{C}H-$	H	H
phenyl	$-C(CH_3)_2CH_2CH_2C(CH_3)_2-$	H	H
4-phenylphenyl	$-CH_2CH=CHCH_2-$	H	H
4-phenylphenyl	$-CH_2\underset{\underset{CH_3}{|}}{C}=\underset{\underset{CH_3}{|}}{C}CH_2-$	H	H
4-fluorophenyl	$-CH_2-CH=CHCH_2-$	H	H
4-chlorophenyl	$-CH_2CH_2CH_2CH_2-$	H	H
4-phenoxyphenyl	$-CH_2CH_2CH_2\underset{\underset{n\text{-}C_4H_9}{|}}{C}H-$	CH_3	CH_3
3-trifluoromethylphenyl	$-\underset{\underset{CH_3}{|}}{C}HCH=CH\underset{\underset{CH_3}{|}}{C}H-$	H	CH_3
2-methoxyphenyl	$-CH_2\underset{\underset{CH_3}{|}}{C}H-\underset{\underset{CH_3}{|}}{C}HCH_2-$	H	H

Example 37

Preparation of (1,1'-Biphenyl-4-yl)dimethyl(1H-imidazol-1-ylmethyl)silane

A mixture of 2.6 g (0.010 mol) of (1,1'-biphenyl-4-yl)chloromethyldimethylsilane and 1.1 g (0.012 mol) of imidazole sodium salt in 5 ml of dimethylformamide was warmed to 80-90° for 2 hours, cooled, diluted with water, and extracted with ether. The ether solution was washed with water and brine, dried over magnesium sulfate, and evaporated to leave 2.0 g of a viscous, pale yellow oil. Trituration of a small sample with hexanes gave a solid. The bulk of the crude product was then taken up in a hot mixture of 20 ml of hexanes and 3 ml of ethyl acetate, the solution was cooled slowly, and seed crystals were added when cloudiness was observed. The resulting crystals were collected and dried to give 0.84 g (29%) of the title compound as colorless flakes: m.p. 51-53°; ir (Nujol^{R}) 1235, 1215, 1105, 1065, 900, 830, 785, 750, 730, 685 cm^{-1}; nmr ($CDCl_3$) 0.4 (6H, s), 3.7 (2H, s), 6.7 (1H, broad s), 7.0 (1H, broad s), 7.1-7.8 (10H, m); analysis for $C_{18}H_{20}N_2Si$ (mw 292.45):

Calculated C, 73.92; H, 6.89; N, 9.58;
Found C, 73.4; H, 7.0; N, 9.4;
73.7; 7.0; 9.4.

Example 38

Preparation of (4-Chlorophenyl)dimethyl(1H-imidazol--1-ylmethyl)silane

A mixture of 2.2 g (0.010 mol) of chloromethyl(4-chlorophenyl)dimethylsilane and 1.1 g (0.012 mol) of imidazole sodium salt in 5 ml of dimethylformamide was stirred at 80-90° for 2 hours, cooled, diluted with water, and extracted with ether. The ether solution was washed with water and brine, dried over magnesium sulfate, and evaporated to leave 2.0 g (81%) of the title compound as a yellow liquid: n_D^{20} 1.5472; ir (neat) 1560, 1495, 1480, 1375, 1250, 1105, 1080, 905, 830, 810, 740 cm^{-1}; nmr ($CDCl_3$) 0.3 (6H, s), 3.6 (2H, s), 6.6 (1H, broad s), 6.9 (1H, broad s), 7.1 (1H, broad s), 7.3 (4H, s).

Example 39

Preparation of (2,4-Dichlorophenyl)dimethyl(1H-imidazol-1-ylmethyl)silane

A mixture of 5.1 g (0.020 mol) of chloromethyl-(2,4-dichlorophenyl)dimethylsilane and 2.0 g (0.022 mol) of imidazole sodium salt in 10 ml of dry dimethylformamide was stirred at 80-90° for 2 hours and worked up as in Example 18 to give 3.9 g (69%) of the title compound as a brown oil: n_D^{23} 1.5637; ir (neat) 1560, 1500, 1450, 1355, 1250, 1105, 1095, 1075, 1025, 840, 780, 735 cm^{-1}; nmr ($CDCl_3$) 0.4 (6H, s), 3.9 (2H, s), 6.7 (1H, broad s), 7.0 (1H, broad s) 7.2-7.5 (4H, m).

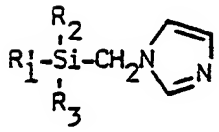
Example 40

Preparation of Diphenyl(1H-imidazol-1-ylmethyl)-methylsilane

A mixture of 4.9 g (0.020 mol) of chloromethyl-(diphenyl)methylsilane and 2.0 g (0.022 mol) of imidazole sodium salt in 10 ml of dry dimethylformamide was stirred at 80°C for 3.5 hours and worked up as in Example 18 to give 4.8 g of a yellow oil. Kugelrohr distillation at 125°/0.05 mm removed volatile impurities, leaving behind 2.9 g (52%) of the title compound as an oil: n_D^{22} 1.5995; ir (neat) 3375, 3250, 1500, 1430, 1255, 1230, 1110, 1075, 1025, 810, 790, 735, 700, 660 cm^{-1}; nmr ($CDCl_3$) 0.6 (3H, s), 3.9 (2H, s), 6.6 (1H, broad s), 6.9 (1H, broad s), 7.2-7.5 (11H, m).

By applying the procedures of Example 37-40 to appropriate chloromethylsilanes, the compounds of Table XIV can be prepared.

Table XIV



R_1'	R_2	R_3	
CH_3	CH_3	CH_3	n_D^{22} 1.4805
C_2H_5	CH_3	CH_3	n_D^{22} 1.4848
$\underline{i}$-C_3H_7	CH_3	CH_3	
$\underline{n}$-C_4H_9	CH_3	CH_3	n_D^{19} 1.4811
$\underline{t}$-C_4H_9	CH_3	CH_3	
$\underline{n}$-$C_{12}H_{25}$	CH_3	CH_3	n_D^{23} 1.4585
$\underline{n}$-$C_{14}H_{29}$	CH_3	CH_3	
$\underline{n}$-$C_{18}H_{37}$	CH_3	CH_3	n_D^{21} 1.4639
cyclopropyl	CH_3	CH_3	
cyclobutyl	CH_3	CH_3	
cyclopentyl	CH_3	CH_3	
cyclohexyl	CH_3	CH_3	n_D^{22} 1.4999
1-naphthyl	CH_3	CH_3	n_D^{23} 1.6188
2-naphthyl	CH_3	CH_3	
phenyl	CH_3	CH_3	bp 120-125° (0.05 mm)
4-bromophenyl	CH_3	CH_3	n_D^{20} 1.5741
4-fluorophenyl	CH_3	CH_3	n_D^{23} 1.5314
4-methoxyphenyl	CH_3	CH_3	n_D^{25} 1.5485
4-phenoxyphenyl	CH_3	CH_3	n_D^{22} 1.5833
4-(4-chlorophenoxy)phenyl	CH_3	CH_3	n_D^{22} 1.5564
4-(4-fluorophenoxy)phenyl	CH_3	CH_3	
4-(4-trifluoromethylphenoxy)phenyl	CH_3	CH_3	
4-(4-methylphenoxy)phenyl	CH_3	CH_3	

Table XIV (continued)

R_1	R_2	R_3	
4-thiomethylphenyl	CH_3	CH_3	n_D^{23} 1.5855
4-methylsulfonylphenyl	CH_3	CH_3	n_D^{21} 1.5552
4-trifluoromethylphenyl	CH_3	CH_3	n_D^{22} 1.4867
4-methylphenyl	CH_3	CH_3	n_D^{21} 1.5482
4-i-propylphenyl	CH_3	CH_3	
4-t-butylphenyl	CH_3	CH_3	n_D^{23} 1.5229
4-cyclohexylphenyl	CH_3	CH_3	n_D^{22} 1.5085
4-trifluoromethoxyphenyl	CH_3	CH_3	n_D^{22} 1.4888
4-(4-chlorophenyl)phenyl	CH_3	CH_3	
4-(4-methylphenyl)phenyl	CH_3	CH_3	
4-(4-trifluoromethylphenyl)phenyl	CH_3	CH_3	
4-(4-fluorophenyl)phenyl	CH_3	CH_3	
4-(4-bromophenyl)phenyl	CH_3	CH_3	n_D^{22} 1.5745
3-phenylphenyl	CH_3	CH_3	n_D^{21} 1.6002
3-trifluoromethylphenyl	CH_3	CH_3	n_D^{20} 1.4927
3-chlorophenyl	CH_3	CH_3	n_D^{22} 1.5560
2-trifluoromethylphenyl	CH_3	CH_3	n_D^{23} 1.5056
2-phenylphenyl	CH_3	CH_3	n_D^{22} 1.5996
2-chlorophenyl	CH_3	CH_3	n_D^{22} 1.5382
2-methoxyphenyl	CH_3	CH_3	n_D^{22} 1.5344
2,3-dimethylphenyl	CH_3	CH_3	
2,3-dimethoxyphenyl	CH_3	CH_3	n_D^{22} 1.5350
2,4-difluorophenyl	CH_3	CH_3	
2-fluoro-4-chlorophenyl	CH_3	CH_3	
2-chloro-4-fluorophenyl	CH_3	CH_3	
2-chloro-4-phenylphenyl	CH_3	CH_3	
2-[illegible]-4-phenylphenyl			
2-methyl-5-chlorophenyl	CH_3	CH_3	

Table XIV (continued)

R_1'	R_2	R_3	
2,6-dimethoxyphenyl	CH_3	CH_3	n_D^{23} 1.5348
2,6-dimethylphenyl	CH_3	CH_3	
3,4-dichlorophenyl	CH_3	CH_3	n_D^{23} 1.5673
3-methyl-4-fluorophenyl	CH_3	CH_3	
3,5-dichlorophenyl	CH_3	CH_3	n_D^{22} 1.5461
C_2H_5	C_2H_5	CH_3	
i-C_3H_7	cyclohexyl	CH_3	
n-C_4H_9	n-C_4H_9	CH_3	n_D^{22} 1.4710
n-$C_{10}H_{21}$	cyclopropyl	CH_3	
n-$C_{12}H_{25}$	n-C_3H_7	CH_3	
n-$C_{14}H_{29}$	i-C_3H_7	CH_3	
n-$C_{18}H_{37}$	3-methylbutyl	CH_3	
cyclopropyl	n-C_6H_{13}	CH_3	
cyclopentyl	cylopentyl	CH_3	
cyclohexyl	cyclohexyl	CH_3	
1-naphthyl	n-C_4H_9	CH_3	
1-naphthyl	t-C_4H_9	CH_3	
2-naphthyl	n-C_5H_{11}	CH_3	
phenyl	n-C_3H_7	CH_3	
phenyl	n-C_4H_9	CH_3	n_D^{22} 1.5449
phenyl	1,1-dimethylpropyl	CH_3	
phenyl	n-C_6H_{13}	CH_3	
4-phenylphenyl	C_2H_5	CH_3	
4-phenylphenyl	n-C_4H_9	CH_3	n_D^{22} 1.5880
4-bromophenyl	i-C_3H_7	CH_3	
4-chlorophenyl	n-C_4H_9	CH_3	n_D^{21} 1.5415
4-fluorophenyl	n-C_4H_9	CH_3	n_D^{22} 1.5161
4-phenoxyphenyl	t-C_4H_9	CH_3	
4-i-propylphenyl	cyclopropyl	CH_3	
4-t-butylphenyl	i-C_4H_9	CH_3	

Table XIV (continued)

R_1'	R_2	R_3	
3-phenylphenyl	i-C_4H_9	CH_3	
3-trifluoromethylphenyl	s-C_4H_9	CH_3	
3-chlorophenyl	n-C_5H_{11}	CH_3	
2-methoxyphenyl	t-C_4H_9	CH_3	
2-thiomethylphenyl	cyclobutyl	CH_3	
2-phenylphenyl	i-C_4H_9	CH_3	
2,4-dichlorophenyl	n-C_4H_9	CH_3	n_D^{21} 1.5588
2,4-dichlorophenyl	cyclopropyl	CH_3	
2,3-dimethylphenyl	n-C_3H_7	CH_3	
2-methyl-5-fluorophenyl	cyclopentyl	CH_3	
2,5-dimethoxyphenyl	4-methylpentyl	CH_3	
2,6-dimethylphenyl	1-methylbutyl	CH_3	
3,4-dichlorophenyl	n-C_5H_{11}	CH_3	
3,5-dichlorophenyl	n-C_4H_9	CH_3	
3,5-dichlorophenyl	cyclohexyl	CH_3	
3-methyl-4-chlorophenyl	cyclopropyl	CH_3	
4-fluorophenyl	phenyl	CH_3	n_D^{19} 1.5810
4-chlorophenyl	phenyl	CH_3	n_D^{21} 1.6000
4-bromophenyl	phenyl	CH_3	n_D^{22} 1.6115
4-phenylphenyl	phenyl	CH_3	n_D^{21} 1.6378
4-t-butylphenyl	phenyl	CH_3	
4-thiomethylphenyl	phenyl	CH_3	
4-phenoxyphenyl	phenyl	CH_3	
4-trifluoromethoxyphenyl	phenyl	CH_3	
4-methylsulfonylphenyl	phenyl	CH_3	
4-cyclohexylphenyl	phenyl	CH_3	
4-(4-fluorophenyl)phenyl	phenyl	CH_3	
3-trifluoromethylphenyl	phenyl	CH_3	
2-chlorophenyl	phenyl	CH_3	n_D^{22} 1.6[illegible]
[illegible]phenyl	phenyl		

Table XIV (continued)

R_1	R_2	R_3	
2,4-dichlorophenyl	phenyl	CH_3	n_D^{22} 1.6150
2-chloro-4-phenylphenyl	phenyl	CH_3	
2-fluoro-4-phenylphenyl	phenyl	CH_3	
3,5-dichlorophenyl	phenyl	CH_3	
2,5-dimethoxyphenyl	phenyl	CH_3	
2,6-dimethoxyphenyl	phenyl	CH_3	
4-fluorophenyl	4-fluorophenyl	CH_3	n_D^{22} 1.5569
4-chlorophenyl	4-chlorophenyl	CH_3	n_D 1.5820
4-bromophenyl	4-bromophenyl	CH_3	n_D^{21} 1.6305
4-phenylphenyl	4-phenylphenyl	CH_3	m.p. 44-53°
4-methoxyphenyl	4-methoxyphenyl	CH_3	n_D^{21} 1.5947
3-trifluoromethylphenyl	3-trifluoromethylphenyl	CH_3	
2-chlorophenyl	2-chlorophenyl	CH_3	n_D^{20} 1.5999
2-methoxyphenyl	2-methoxyphenyl	CH_3	
2,4-dichlorophenyl	2,4-dichlorophenyl	CH_3	n_D^{22} 1.6019
3,5-dichlorophenyl	3,5-dichlorophenyl	CH_3	
2-chlorophenyl	4-chlorophenyl	CH_3	n_D^{20} 1.6044
2-chlorophenyl	4-fluorophenyl	CH_3	
4-phenylphenyl	4-chlorophenyl	CH_3	
4-phenylphenyl	4-fluorophenyl	CH_3	
4-phenylphenyl	2,4-dichlorophenyl	CH_3	
4-fluorophenyl	2,4-dichlorophenyl	CH_3	
4-chlorophenyl	2,4-dichlorophenyl	CH_3	
1-naphthyl	2,6-dimethoxyphenyl	CH_3	
4-phenoxyphenyl	3,4-dichlorophenyl	CH_3	
C_2H_5	C_2H_5	C_2H_5	
i-C_3H_7	i-C_3H_7	i-C_3H_7	
n-C_4H_9	n-C_4H_9	n-C_4H_9	
n-C_8H_{17}	C_2H_5	cyclopentyl	
n-$C_{14}H_{29}$	cyclopropyl	1-methylbutyl	

Table XIV (continued)

R_1	R_2	R_3
n-$C_{18}H_{37}$	n-C_6H_{13}	n-C_6H_{13}
cyclopropyl	C_2H_5	s-C_4H_9
cyclohexyl	n-C_3H_7	n-C_3H_7
1-naphthyl	n-C_4H_9	n-C_4H_9
2-naphthyl	n-C_4H_9	cyclobutyl
phenyl	cyclopropyl	n-C_6H_{13}
4-phenylphenyl	C_2H_5	C_2H_5
4-phenylphenyl	n-C_4H_9	n-C_4H_9
4-phenylphenyl	n-C_6H_{13}	n-C_6H_{13}
4-phenylphenyl	cyclohexyl	cyclohexyl
4-chlorophenyl	n-C_4H_9	n-C_4H_9
4-fluorophenyl	n-C_3H_7	n-C_3H_7
4-phenoxyphenyl	n-C_4H_9	cyclohexyl
4-(4-chlorophenoxy)phenyl	n-C_4H_9	n-C_4H_9
4-t-butylphenyl	s-C_4H_9	i-C_4H_9
3-methoxyphenyl	C_2H_5	t-C_4H_9
3-trifluoromethylphenyl	s-C_4H_9	s-C_4H_9
2-thiomethylphenyl	i-C_3H_7	3-methylbutyl
2-phenylphenyl	cyclohexyl	cyclohexyl
2,4-dichlorophenyl	n-C_4H_9	n-C_4H_9
2,6-dimethylphenyl	t-C_4H_9	t-C_4H_9
3,5-dichlorophenyl	cyclopentyl	cyclopentyl
3-methyl-4-chlorophenyl	s-C_4H_9	s-C_4H_9
2-methyl-5-fluorophenyl	n-C_4H_9	i-C_4H_9
C_2H_5	phenyl	phenyl
cyclohexyl	phenyl	phenyl
n-$C_{18}H_{37}$	phenyl	phenyl
n-C_4H_9	4-chlorophenyl	4-chlorophenyl
n-$C_{12}H_{25}$	4-chlorophenyl	4-chlorophenyl
1-naphthyl	4-fluorophenyl	4-fluorophenyl
[illegible]	phen[illegible]	[illegible]
n-C_4H_9	phen[illegible]	[illegible]

Table XIV (continued)

R_1'	R_2	R_3
t-C_4H_9	phenyl	2,4-dichlorophenyl
n-C_3H_7	phenyl	3-trifluoromethylphenyl
i-C_4H_9	phenyl	3,5-dichlorophenyl
cyclopentyl	phenyl	2,6-dimethoxyphenyl
n-$C_{14}H_{29}$	4-chlorophenyl	2-fluorophenyl
n-C_4H_9	4-fluorophenyl	4-phenylphenyl
phenyl	phenyl	phenyl m.p. 175-178°
4-chlorophenyl	4-chlorophenyl	4-chlorophenyl
4-fluorophenyl	4-fluorophenyl	4-fluorophenyl
4-phenylphenyl	4-phenylphenyl	4-phenylphenyl
2,4-dichlorophenyl	2,4-dichlorophenyl	2,4-dichlorophenyl
phenyl	4-fluorophenyl	4-fluorophenyl
phenyl	4-chlorophenyl	4-chlorophenyl
phenyl	4-phenylphenyl	4-phenylphenyl
phenyl	2,4-dichlorophenyl	2,4-dichlorophenyl
2-naphthyl	4-methylthiophenyl	4-methylthiophenyl
4-chlorophenyl	2-methoxyphenyl	2-methoxyphenyl
4-chlorophenyl	3-chlorophenyl	3-chlorophenyl
phenyl	2-chlorophenyl	4-fluorophenyl
phenyl	4-chlorophenyl	4-phenylphenyl
1-naphthyl	4-bromophenyl	3-methylphenyl
4-phenoxyphenyl	3,5-dimethylphenyl	3,4-dichlorophenyl

Example 41

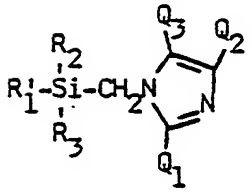
Preparation of (1,1'-Biphenyl-4-yl)dimethyl(2-methyl-1H-imidazol-1-ylmethyl)silane

The title compound is prepared by applying the procedure of Example 37 to (1,1'-biphenyl-4-yl)chloromethyldimethylsilane and the sodium salt of 2-methylimidazole.

Related compounds may be made in this way using salts of 2,4-dimethylimidazole, 4,5-dimethylimidazole, and 2,4,5-trimethylimidazole.

The procedure of Example 41 may be used to prepare the compounds of Table XV.

Table XV



R_1'	R_2	R_3	Q_1	Q_2	Q_3
C_2H_5	CH_3	CH_3	CH_3	CH_3	CH_3
n-$C_{18}H_{37}$	CH_3	CH_3	H	CH_3	CH_3
cyclohexyl	CH_3	CH_3	H	CH_3	CH_3
1-naphthyl	CH_3	CH_3	CH_3	H	H
phenyl	CH_3	CH_3	H	CH_3	H
phenyl	CH_3	CH_3	H	H	CH_3
4-phenylphenyl	CH_3	CH_3	CH_3	H	H
4-(4-fluorophenyl)phenyl	CH_3	CH_3	CH_3	H	H
4-phenoxyphenyl	CH_3	CH_3	CH_3	CH_3	CH_3
3-trifluoromethylphenyl	CH_3	CH_3	H	CH_3	CH_3
2-methoxyphenyl	CH_3	CH_3	CH_3	H	H
2,4-dichlorophenyl	CH_3	CH_3	CH_3	CH_3	CH_3
2-chloro-4-phenylphenyl	CH_3	CH_3	H	CH_3	CH_3
phenyl	n-C_4H_9	CH_3	CH_3	H	H
4-phenylphenyl	n-C_4H_9	CH_3	H	CH_3	CH_3
2,4-dichlorophenyl	n-C_6H_{13}	CH_3	CH_3	H	H
4-(4-chlorophenoxy)phenyl	cyclohexyl	CH_3	CH_3	H	H
phenyl	phenyl	CH_3	CH_3	CH_3	CH_3
4-fluorophenyl	phenyl	CH_3	CH_3	H	H
4-fluorophenyl	phenyl	CH_3	CH_3	CH_3	CH_3
4-chlorophenyl	phenyl	CH_3	H	CH_3	CH_3
4-fluorophenyl	4-fluorophenyl	CH_3	CH_3	H	H
4-fluorophenyl	4-fluorophenyl	CH_3	H	CH_3	CH_3
4-chlorophenyl	4-chlorophenyl	CH_3	Cl	CH_3	CH_3
[illegible]	[illegible]	[illegible]			

Table XV (continued)

R_1	R_2	R_3	Q_1	Q_2	Q_3
2-chlorophenyl	4-chlorophenyl	CH_3	CH_3	CH_3	CH_3
2,4-dichlorophenyl	2,4-dichlorophenyl	CH_3	CH_3	H	H
n-$C_{18}H_{37}$	n-C_6H_{13}	n-C_6H_{13}	H	CH_3	CH_3
1-naphthyl	n-C_4H_9	n-C_4H_9	CH	CH_3	CH_3
phenyl	phenyl	phenyl	CH_3	H	H
phenyl	phenyl	phenyl	CH_3	H	CH_3
phenyl	phenyl	phenyl	CH_3	CH_3	H

Example 42

Preparation of the 1:1 complex of (1,1'-Biphenyl-4-yl)-dimethyl(1H-imidazol-1-ylmethyl)silane and Cuprous Chloride

A mixture of 0.50 g (0.0017 mol) of (1,1'-biphenyl-4-yl)dimethyl(1H-imidazol-1-ylmethyl)silane and 0.22 g (0.0017 mol) of cuprous chloride in 15 ml of tetrahydrofuran was refluxed under N_2 for 15 minutes, and the resulting deep green solution was evaporated to leave the title complex as a dark green solid: m.p. 72-80° (decomp.); ir (Nujol^R) 1590, 1515, 1250, 1110, 840, 820, 750, 695, 650 cm^{-1}.

By applying the procedure of Example 24, any of the compounds of Tables XIV, XV, XVI, XVII, XVIII or XIX can be converted to metal complexes or salts.

Example 43

Preparation of (1,1-'Biphenyl-4-yl)(1H-imidazol-1-ylmethyl)(methoxy)methylsilane

A mixture of (1,1'-biphenyl-4-yl)chloro(chloromethyl)methylsilane and two equivalents of imidazole sodium salt in dimethylformamide is warmed to 80-90°C for 2 hours. Ten equivalents of methanol is then added, and the mixture is held at 70° for 1 hour, cooled, diluted with water, and quickly extracted with ether. Washing the ether solution with water and brine, drying over magnesium sulfate, and evaporation leaves the title compound.

Related compounds can be made in the same way, using the appropriate chlorosilane and alcohol; for R_6 = OH, water is used instead of an alcohol, and hydrolysis is conducted at 20-25° instead of 70°.

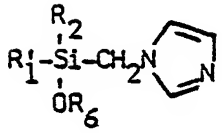
Example 44

Preparation of 1,1-(Dimethylethoxy)(1H-imidazol-1-ylmethyl)methyl(phenyl)silane

A mixture of 3.6 g (0.015 mol) of chloromethyl-(1,1-dimethylethoxy)methyl(phenyl)silane and 1.3 g (0.015 mol) of imidazole sodium salt in 10 ml of dimethylformamide was stirred at 50° for 3 hours, allowed to stand at room temperature for 72 hours, poured into water, and extracted with ether. The ether extracts were washed three times with water and once with brine, dried over magnesium sulfate, and evaporated to leave 3.8 g of an oil. Impurities were removed by Kugelrohr distillation at 90° (airbath)/ 0.05 mm to leave 2.9 g (71%) of the title compound as a pale yellow oil: n_D^{20} 1.5291; ir (neat) 3105, 3070, 3045, 2970, 1590, 1500, 1425, 1360, 1250, 1235, 1185, 1110, 1055, 1020, 900, 805, 740, 700, 660 cm^{-1}; nmr ($CDCl_3$): 0.6 (3H, s), 1.3 (9H, s), 3.6 (2H, s), 6.8 (1H, s), 7.0 (1H, s) and 7.3-7.7 (6H, m).

The compounds of Tables XVI and XVII can be made using the procedures of Examples 43 and 44.

Table XVI



R_1'	R_2	R_6	
C_2H_5	CH_3	CH_3	
t-C_4H_9	CH_3	t-C_4H_9	
n-C_4H_9	CH_3	C_2H_5	
n-$C_{12}H_{25}$	C_2H_5	CH_3	
n-$C_{18}H_{37}$	n-C_6H_{13}	CH_3	
cyclopropyl	CH_3	s-C_4H_9	
cyclohexyl	CH_3	CH_3	
1-naphthyl	i-C_3H_7	i-C_3H_7	
2-naphthyl	cyclobutyl	n-C_3H_7	
phenyl	CH_3	H	
phenyl	CH_3	CH_3	
phenyl	CH_3	C_2H_5	
phenyl	CH_3	i-C_3H_7	n_D^{20} 1.5352
phenyl	t-C_4H_9	H	
4-phenylphenyl	n-C_4H_9	CH_3	
4-phenylphenyl	t-C_4H_9	H	
4-phenylphenyl	CH_3	C_2H_5	
4-phenylphenyl	CH_3	n-C_4H_9	
4-chlorophenyl	n-C_4H_9	n-C_4H_9	
4-chlorophenyl	CH_3	CH_3	
4-chlorophenyl	CH_3	C_2H_5	
4-fluorophenyl	n-C_6H_{13}	n-C_3H_7	
4-fluorophenyl	CH_3	C_2H_5	
4-phenoxyphenyl	cyclohexyl	i-C_4H_9	
4-t-butylphenyl	n-C_3H_7	s-C_4H_9	
3-trifluoromethylphenyl	t-C_4H_9	H	
2-methylthiophenyl	cyclopentyl	C_2H_5	

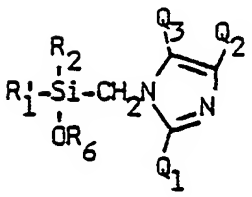
Table XVI (continued)

R_1'	R_2	R_6
2,4-dichlorophenyl	CH_3	CH_3
2,4-dichlorophenyl	CH_3	C_2H_5
2,4-dichlorophenyl	CH_3	t-C_4H_9
2,4-dichlorophenyl	n-C_4H_9	C_2H_5
2,3-dimethylphenyl	cyclopropyl	i-C_3H_7
2-methyl-5-fluorophenyl	s-C_4H_9	n-C_3H_7
2,6-dimethoxyphenyl	1,1-dimethylpropyl	H
3-methyl-4-chlorophenyl	C_2H_5	CH_3
3,5-dichlorophenyl	n-C_5H_{11}	C_2H_5
n-$C_{12}H_{25}$	2,4-dichlorophenyl	t-C_4H_9
n-$C_{18}H_{37}$	phenyl	CH_3
1-naphthyl	phenyl	C_2H_5
phenyl	phenyl	t-C_4H_9
4-fluorophenyl	phenyl	CH_3
4-chlorophenyl	phenyl	n-C_3H_7
4-phenylphenyl	phenyl	C_2H_5
4-phenylphenyl	phenyl	s-C_4H_9
4-t-butylphenyl	phenyl	s-C_4H_9
3-fluorophenyl	phenyl	C_2H_5
2-methoxyphenyl	phenyl	H
2-chlorophenyl	phenyl	CH_3
2,4-dichlorophenyl	phenyl	i-C_3H_7
3,5-dichlorophenyl	phenyl	n-C_3H_7
4-fluorophenyl	4-fluorophenyl	t-C_4H_9
4-fluorophenyl	4-fluorophenyl	C_2H_5
4-chlorophenyl	4-chlorophenyl	CH_3
4-chlorophenyl	4-chlorophenyl	C_2H_5
4-phenylphenyl	4-phenylphenyl	CH_3
2,4-dichlorophenyl	2,4-dichlorophenyl	C_2H_5
3-trifluoromethylphenyl	3-trifluoromethylphenyl	i-C_4H_9
2-methoxyphenyl	2-methoxyphenyl	H
2-chlorophenyl	4-fluorophenyl	H

Table XVI (continued)

R_1'	R_2	R_6
3-trifluoromethylphenyl	4-t-butylphenyl	n-C_4H_9
2-fluoro-4-chlorophenyl	4-bromophenyl	i-C_3H_7
2,3-dimethylphenyl	4-methylthiophenyl	C_2H_5
2,6-dimethoxyphenyl	4-methoxyphenyl	H
3,4-dichlorophenyl	4-methylphenyl	i-C_4H_9

Table XVII



R_1'	R_2	R_6	Q_1	Q_2	Q_3
C_2H_5	CH_3	CH_3	CH_3	CH_3	CH_3
cyclohexyl	CH_3	$\underline{i}$-C_3H_7	H	CH_3	CH_3
$\underline{n}$-$C_{18}H_{37}$	$\underline{n}$-C_6H_{13}	$\underline{t}$-C_4H_9	CH_3	H	H
1-naphthyl	CH_3	$\underline{i}$-C_3H_7	CH_3	H	H
phenyl	CH_3	$\underline{t}$-C_4H_9	H	CH_3	H
phenyl	CH_3	$\underline{t}$-C_4H_9	H	H	CH_3
phenyl	CH_3	$\underline{t}$-C_4H_9	CH_3	CH_3	CH_3
phenyl	CH_3	$\underline{s}$-C_4H_9	H	CH_3	CH_3
phenyl	CH_3	$\underline{i}$-C_4H_9	CH_3	H	H
4-phenylphenyl	$\underline{n}$-C_4H_9	$\underline{t}$-C_4H_9	CH_3	CH_3	CH_3
4-phenylphenyl	CH_3	$\underline{t}$-C_4H_9	CH_3	H	H
4-phenylphenyl	CH_3	$\underline{t}$-C_4H_9	CH_3	CH_3	CH_3
4-chlorophenyl	CH_3	$\underline{t}$-C_4H_9	CH_3	H	H
4-chlorophenyl	CH_3	$\underline{t}$-C_4H_9	H	CH_3	CH_3
4-fluorophenyl	CH_3	$\underline{t}$-C_4H_9	H	CH_3	H
4-fluorophenyl	CH_3	$\underline{t}$-C_4H_9	H	H	CH_3
phenyl	phenyl	C_2H_5	CH_3	CH_3	CH_3
phenyl	phenyl	$\underline{n}$-C_3H_7	CH_3	CH_3	CH_3
4-fluorophenyl	phenyl	$\underline{i}$-C_3H_7	H	CH_3	CH_3
4-fluorophenyl	phenyl	$\underline{t}$-C_4H_9	CH_3	H	H
4-chlorophenyl	phenyl	$\underline{i}$-C_3H_7	CH_3	H	H
2,4-dichlorophenyl	phenyl	H	CH_3	H	H
4-fluorophenyl	4-fluorophenyl	$\underline{t}$-C_4H_9	CH_3	H	H
4-fluorophenyl	4-fluorophenyl	$\underline{t}$-C_4H_9	H	CH_3	CH_3
4-fluorophenyl	4-fluorophenyl	$\underline{t}$-C_4H_9	CH_3	CH_3	CH_3
2-methoxyphenyl	2-methoxyphenyl	C_2H_5	CH_3	H	H
3-methylphenyl	3-methylphenyl	$\underline{i}$-C_4H_9	CH_3	H	H

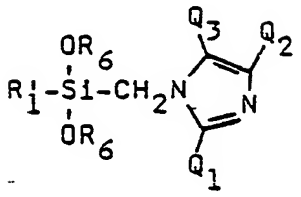
Example 45

Preparation of (1H-Imidazol-1-ylmethyl)phenylbis(2-propoxy)silane

The title compound can be made by applying the procedure of Example 26 to chloromethyl(phenyl)bis-(2-propoxy)silane: n_D^{22} 1.4971; nmr ($CDCl_3$) 1.2 (12H, d, J = 6), 3.6 (2H, s), 4.2 (2H, septet, J = 6), 6.8-7.6 (8H, m).

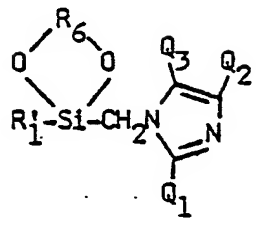
The compounds of Tables XVIII and XIX can be made similarly.

Table XVIII



R_1'	R_6	Q_1	Q_2	Q_3
C_2H_5	t-C_4H_9	H	H	H
n-C_4H_9	C_2H_5	H	H	H
n-$C_{18}H_{37}$	CH_3	H	H	H
cyclohexyl	n-C_3H_7	H	H	H
1-naphthyl	i-C_4H_9	H	H	H
phenyl	CH_3	CH_3	CH_3	CH_3
phenyl	n-C_3H_7	CH_3	H	H
phenyl	i-C_3H_7	H	CH_3	CH_3
phenyl	t-C_4H_9	H	H	H
4-phenylphenyl	C_2H_5	H	H	H
4-phenylphenyl	n-C_4H_9	CH_3	CH_3	CH_3
4-fluorophenyl	CH_3	CH_3	H	H
4-fluorophenyl	C_2H_5	H	H	H
4-chlorophenyl	C_2H_5	H	H	H
4-chlorophenyl	i-C_3H_7	H	H	H
3-trifluoromethylphenyl	s-C_4H_9	CH_3	CH_3	CH_3
2-methoxyphenyl	n-C_3H_7	CH_3	H	H
2,3-dimethylphenyl	i-C_4H_9	H	H	H
2,4-dichlorophenyl	CH_3	H	H	H
2,4-dichlorophenyl	C_2H_5	H	H	H
2-methoxy-5-fluorophenyl	i-C_3H_7	H	H	H
2,6-dimethoxyphenyl	CH_3	H	H	H
3,4-dichlorophenyl	C_2H_5	H	H	H
3,5-dichlorophenyl	n-C_4H_9	H	H	H

Table XIX



R_1'	R_6	Q_1	Q_2	Q_3
C_2H_5	$-CH_2CH_2-$	H	H	H
	$-CH_2\overset{CH_3}{\overset{\vert}{C}}H-$			
$n-C_4H_9$	$-CH_2\overset{CH_3}{\overset{\vert}{C}}H-$	CH_3	H	H
$n-C_{18}H_{37}$	$-CH_2CH_2CH_2-$	H	CH_3	CH_3
	$-CH_2\overset{C_2H_5}{\overset{\vert}{C}}H-$			
cyclohexyl	$-CH_2\overset{C_2H_5}{\overset{\vert}{C}}H-$	CH_3	CH_3	CH_3
1-naphthyl	$-CH_2CH_2-$	CH_3	H	H
phenyl	$-CH_2CH_2-$	H	H	H
	$-CH_2\overset{C_2H_5}{\overset{\vert}{C}}H-$			
phenyl	$-CH_2\overset{C_2H_5}{\overset{\vert}{C}}H-$	H	H	H
	$-CH_2\overset{n-C_3H_7}{\overset{\vert}{C}}H-$			
phenyl	$-CH_2\overset{n-C_3H_7}{\overset{\vert}{C}}H-$	H	H	H
phenyl	$-C(CH_3)_2C(CH_3)_2-$	H	H	H
4-phenylphenyl	$-CH_2CH_2-$	H	H	H
	$-CH_2\overset{C_2H_5}{\overset{\vert}{C}}H-$			
4-phenylphenyl	$-CH_2\overset{C_2H_5}{\overset{\vert}{C}}H-$	H	H	H
	$-\overset{CH_3}{\overset{\vert}{C}}H-\overset{CH_3}{\overset{\vert}{C}}H-$			
4-phenylphenyl	$-\overset{CH_3}{\overset{\vert}{C}}H-\overset{CH_3}{\overset{\vert}{C}}H-$	H	H	H
4-fluorophenyl	$-CH_2CH_2-$	H	H	H
	$-CH_2\overset{CH_3}{\overset{\vert}{C}}H-$			
4-fluorophenyl	$-CH_2\overset{CH_3}{\overset{\vert}{C}}H-$	H	H	H
	$-CH_2\overset{C_2H_5}{\overset{\vert}{C}}H-$			
4-chlorophenyl	$-CH_2\overset{C_2H_5}{\overset{\vert}{C}}H-$	H	H	H
4-chlorophenyl	$-C(CH_3)_2C(CH_3)_2-$	H	H	H
	$-\overset{CH_3}{\overset{\vert}{C}}HCH_2C(CH_3)_2-$			
3-trifluoromethylphenyl	$-\overset{CH_3}{\overset{\vert}{C}}HCH_2C(CH_3)_2-$	CH_3	CH_3	CH_3

Table XIX (continued)

R_1	R_6	Q_1	Q_2	Q_3
2-methoxyphenyl	$-CH_2\underset{\underset{n\text{-}C_4H_9}{|}}{CH}-$	CH_3	H	H
2,3-dimethylphenyl	$-CH_2CH_2-$	H	CH_3	CH_3
2,4-dichlorophenyl	$-CH_2\underset{\underset{C_2H_5}{|}}{CH}-$	H	H	H
2,4-dichlorophenyl	$-CH_2\underset{\underset{n\text{-}C_3H_7}{|}}{CH}-$	H	H	H
2-methoxy-5-fluorophenyl	$-\underset{\underset{CH_3}{|}}{CH}C(CH_3)_2\underset{\underset{CH_3}{|}}{CH}-$	CH_3	H	H
2,6-dimethoxyphenyl	$-CH_2CH_2-$	H	H	H
3,4-dichlorophenyl	$-\underset{\underset{CH_3}{|}}{CH}CH_2\underset{\underset{CH_3}{|}}{CH}-$	CH_3	CH_3	CH_3
3,5-dichlorophenyl	$-\underset{\underset{CH_3}{|}}{CH}-\underset{\underset{CH_3}{|}}{CH}-$	CH_3	CH_3	CH_3
C_2H_5	$-CH_2CH=CHCH_2-$	H	CH_3	CH_3
$n\text{-}C_{18}H_{37}$	$-\underset{\underset{CH_3}{|}}{CH}CH_2CH_2\underset{\underset{CH_3}{|}}{CH}-$	H	CH_3	CH_3
phenyl	$-CH_2CH=CHCH_2-$	H	H	H
phenyl	$-C(CH_3)_2CH=CHC(CH_3)_2-$	H	H	H
phenyl	$-\underset{\underset{CH_3}{|}}{CH}CH_2CH_2\underset{\underset{CH_3}{|}}{CH}-$	H	H	H
phenyl	$-C(CH_3)_2CH_2CH_2C(CH_3)_2-$	H	H	H
4-phenylphenyl	$-CH_2CH=CHCH_2-$	H	H	H
4-phenylphenyl	$-CH_2\underset{\underset{CH_3}{|}}{C}=\underset{\underset{CH_3}{|}}{C}CH_2-$	H	H	H
4-fluorophenyl	$-CH_2-CH=CHCH_2-$	H	H	H
4-chlorophenyl	$-CH_2CH_2CH_2CH_2-$	H	H	H
4-phenoxyphenyl	$-CH_2CH_2CH_2\underset{\underset{n\text{-}C_4H_9}{|}}{CH}-$	CH_3	H	H
3-trifluoromethylphenyl	$-\underset{\underset{CH_3}{|}}{CH}CH=\underset{\underset{CH_3}{|}}{CH}-$	H	CH_3	CH_3
2-methoxyphenyl	$-CH_2\underset{\underset{CH_3}{|}}{CH}-\underset{\underset{CH_3}{|}}{CH}CH_2-$	CH_3	CH_3	CH_3

Formulations

Useful formulations of the compounds within the scope of this invention can be prepared in conventional ways. They include dusts, granules, pellets, solutions, emulsions, wettable powders, emulsifiable concentrates and the like. Many of these may be applied directly. Sprayable formulations can be extended in suitable media and used at spray volumes of from a few pints to several hundred gallons per acre. High strength compositions are primarily used as intermediates for further formulations. The formulations, broadly, contain about 1% to 99% by weight of active ingredient(s) and at least one of a) about 0.1% to 20% surfactant(s) and b) about 5% to 99% solid or liquid inert diluent(s). More specifically, they will contain these ingredients in the following approximate proportions:

	Percent by Weight		
	Active Ingredient	Diluent(s)	Surfactant(s)
Wettable Powders	20-90	0-74	1-10
Oil Suspensions, Emulsions, Solutions, (including Emulsifiable Concentrates)	5-50	40-95	0-15
Aqueous Suspensions	10-50	40-84	1-20
Dusts	1-25	70-99	0-5
Granules and Pellets	1-95	5-99	0-15
High Strength Compositions	90-99	0-10	0-2

Lower or higher levels of active ingredient can, of course, be present depending on the intended use and the physical properties of the compound. Higher ratios of surfactant to active ingredient are sometimes desirable, and are achieved by incorporation into the formulation or by tank mixing.

Typical solid diluents are described in Watkins, et al., "Handbook of Insecticide Dust Diluents and Carriers", 2nd Ed., Dorland Books, Caldwell, New Jersey. The more absorptive diluents are preferred for the wettable powders and the denser ones for dusts. Typical liquid diluents and solvents are described in Marsden, "Solvents Guide," 2nd Ed., Interscience, New York, 1950. Solubility under 0.1% is preferred for suspension concentrates; solution concentrates are preferably stable against phase separation at 0°C. "McCutcheon's Detergents and Emulsifiers Annual", MC Publishing Corp., Ridgewood, New Jersey, as well as Sisely and Wood, "Encyclopedia of Surface Active Agents", Chemical Publishing Co., Inc., New York, 1964, list surfactants and recommended uses. All formulations can contain minor amounts of additives to reduce foam, caking, corrosion, microbiological growth, etc.

The methods of making such compositions are well known. Solutions are prepared by simply mixing the ingredients. Fine solid compositions are made by blending and, usually, grinding as in a hammer or fluid energy mill. Suspensions are prepared by wet milling (see, for example, Littler, U.S. Patent 3,060,084). Granules and pellets may be made by spraying the active material upon preformed granular carriers or by agglomeration techniques. See J. E. Browning, "Agglomeration", Chemical Engineering, December 4, 1967, pp. 147ff. and "Perry's Chemical Engineer's Handbook", 4th Ed., McGraw-Hill, New York, 1963, pp. 8-59ff.

Example 46

Wettable Powder

(1,1-Biphenyl-4-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	40%
dioctyl sodium sulfosuccinate	1.5%
sodium ligninsulfonate	3%
low viscosity methyl cellulose	1.5%
attapulgite	54%

The ingredients are thoroughly blended, passed through an air mill, to produce an average particle size under 15 microns, reblended, and sifted through a U.S.S. No. 50 sieve (0.3 mm opening) before packaging.

All compounds of the invention may be formulated in the same manner.

Example 47

Wettable Powder

(4-Bromophenyl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)-silane	20%
sodium alkylnaphthalenesulfonate	2%
low viscosity methyl cellulose	2%
diatomaceous earth	76%

The ingredients are blended, coarsely hammer-milled and then air milled to produce particles of active essentially all below 10 microns in diameter. The product is reblended before packaging.

Example 48

High Strength Concentrate

(4-Chlorophenyl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	98.5%
silica aerogel	0.5%
synthetic amorphous fine silica	1.0%

The ingredients are blended and ground in a hammer-mill to produce a high strength concentrate essentially all passing a U.S.S. No. 50 sieve (0.3 mm openings). This material may then be formulated in a variety of ways.

Example 49

Dust

high strength concentrate from Example 48	25.4%
pyrophyllite, powdered	74.6%

The ingredients are thoroughly blended and packaged for use.

Example 50

Aqueous Suspension

(1,1'-Biphenyl-4-yl)dimethyl(1H-1,2,4-triazol-1-yl-methyl)silane	50.0%
polyacrylic acid thickener	0.3%
dodecylphenyl polyethylene glycol ether	0.5%
disodium phosphate	1.0%
monosodium phosphate	0.5%
polyvinyl alcohol	1.0%
pentachlorophenyl	0.4%
water	46.3%

The ingredients are ground together in a sand mill to produce particles substantially all under five microns in size.

Example 51

Emulsifiable Concentrate

Dimethyl(phenyl)(1H-1,2,4-triazol-1-ylmethyl)-silane	20%
chlorobenzene	74%
sorbitan monostearate and poly-oxyethylene condensates thereof	6%

The ingredients are combined and stirred to produce a solution which can be emulsified in water for application.

Example 52

Emulsifiable Concentrate

Dimethyl(4-methylphenyl)(1H-1,2,4-triazol-1-ylmethyl)-silane	30%
blend of oil soluble sulfonates and polyoxyethylene ethers	4%
xylene	66%

The ingredients are combined and stirred with gentle warming to speed solution. A fine screen filter is included in packaging operation to insure the absence of any extraneous undissolved material in the product.

Example 53

Granule

wettable powder of example 46	15%
gypsum	69%
potassium sulfate	16%

The ingredients are blended in a rotating mixer and water sprayed on to accomplish granulation. When most of the material has reached the desired range of 1.0 to 0.42 mm. (U.S.S. # 18 to 40 sieves), the granules are removed, dried, and screened. Oversize material is crushed to produce additional material in the desired range. These granules contain active ingredient.

Example 54

Emulsifiable Concentrate

(2,4-Dichlorophenyl)dimethyl(1H-1,2,4-triazol-1-yl-methyl)silane	30%
blend of oil soluble sulfonates and polyoxyethylene ethers	4%
xylene	66%

The ingredients are combined and stirred with gentle warming to speed solution. A fine screen filter is included in packaging operation to insure the absence of any extraneous undissolved material in the product.

Example 55

Emulsifiable Concentrate

Butyl(4-chlorophenyl)methyl(1H-1,2,4-triazol-1-yl-methyl)silane	30%
blend of oil soluble sulfonates and polyoxyethylene ethers	4%
xylene	66%

The ingredients are combined and stirred with gentle warming to speed solution. A fine screen filter is included in packaging operation to insure the absence of any extraneous undissolved material in the product.

Example 56

Emulsifiable Concentrate

bis(4-Chlorophenyl)methyl(1H-1,2,4-triazol-1-ylmethyl)-silane	30%
blend of oil soluble sulfonates and polyoxyethylene ethers	4%
xylene	66%

The ingredients are combined and stirred with gentle warming to speed solution. A fine screen filter is included in packaging operation to insure the absence of any extraneous undissolved material in the product.

Example 57

Emulsifiable Concentrate

bis(4-Fluorophenyl)methyl(1H-1,2,4-triazol-1-ylmethyl)-silane	20%
chlorobenzene	74%
sorbitan monostearate and polyoxyethylene condensates thereof	6%

The ingredients are combined and stirred to produce a solution which can be emulsified in water for application.

Example 58

Emulsifiable Concentrate

4-Fluorophenyl(methyl)phenyl(1H-1,2,4-triazol-1-ylmethyl)silane	30%
blend of oil soluble sulfonates and polyoxyethylene ethers	4%
xylene	66%

The ingredients are combined and stirred with gentle warming to speed solution. A fine screen filter is included in packaging operation to insure the absence of any extraneous undissolved material in the product.

Example 59

Wettable Powder

(1,1'-Biphenyl-4-yl)dimethyl(1H-imidazol-1-ylmethyl)-silane	50%
sodium alkylnaphthalenesulfonate	2%
low viscosity methyl cellulose	2%
diatomaceous earth	46%

The ingredients are blended, coarsely hammer-milled and then air milled to produce particles of active essentially all below 10 microns in diameter. The product is reblended before packaging.

Example 60

Wettable Powder

(1,1-Biphenyl-4-yl)dimethyl(1H-imidazol-1-ylmethyl)-silane	40%
dioctyl sodium sulfosuccinate	1.5%
sodium ligninsulfonate	3%
low viscosity methyl cellulose	1.5%
attapulgite	54%

The ingredients are thoroughly blended, passed through an air mill, to produce an average particle size under 15 microns, reblended, and sifted through a U.S.S. No. 50 sieve (0.3 mm opening) before packaging.

All compounds of the invention may be formulated in the same manner.

Example 61

Emulsifiable Concentrate

(1,1'-Biphenyl-4-yl)dimethyl(1H-imidazol-1-ylmethyl)-silane	30%
blend of oil soluble sulfonates and polyoxyethylene ethers	4%
xylene	66%

The ingredients are combined and stirred with gentle warming to speed solution. A fine screen filter is included in packaging operation to insure the absence of any extraneous undissolved material in the product.

Example 62

Emulsifiable Concentrate

(1,1'-Biphenyl-4-yl)dimethyl(1H-imidazol-1-ylmethyl)-silane	20%
chlorobenzene	74%
sorbitan monostearate and polyoxyethylene condensates thereof	6%

The ingredients are combined and stirred to produce a solution which can be emulsified in water for application.

Example 63

Aqueous Suspension

(1,1'-Biphenyl-4-yl)dimethyl(1H-imidazol-1-ylmethyl)-silane	25%
hydrated attapulgite	3%
crude calcium ligninsulfonate	10%
sodium dihydrogen phosphate	0.5%
water	61.5%

The ingredients are ground together in a ball or roller mill until the solid particles have been reduced to diameters under 10 microns.

Example 64

High Strength Concentrate

(1,1'-Biphenyl-4-yl)dimethyl(1H-imidazol-1-ylmethyl)-silane	98.5%
silica aerogel	0.5%
synthetic amorphous fine silica	1.0%

The ingredients are blended and ground in a hammer-mill to produce a high strength concentrate essentially all passing a U.S.S. No. 50 sieve (0.3 mm openings). This material may then be formulated in a variety of ways.

Example 65

Granule

wettable powder of example 60	15%
gypsum	69%
potassium sulfate	16%

The ingredients are blended in a rotating mixer and water sprayed on to accomplish granulation. When most of the material has reached the desired range of 1.0 to 0.42 mm. (U.S.S. # 18 to 40 sieves), the granules are removed, dried, and screened. Oversize material is crushed to produce additional material in the desired range. These granules contain active ingredient.

Example 66

Dust

high strength concentrate from Example 64	25.4%
pyrophyllite, powdered	74.6%

The ingredients are thoroughly blended and packaged for use.

Example 67

Emulsifiable Concentrate

4-Chlorophenyl(methyl)phenyl(1H-imidazol-1-yl-methyl)silane	20%
chlorobenzene	74%
sorbitan monostearate and polyoxyethylene condensates thereof	6%

The ingredients are combined and stirred to produce a solution which can be emulsified in water for application.

Utility

The compounds of this invention are useful as plant disease control agents. They are effective in controlling a broad spectrum of plant diseases, particularly foliar pathogens of ornamental, vegetable, field, cereal and fruit crops, such as, Puccinia recondita, Erysiphe cichoracearum, Erysiphe graminis, Venturia inaequalis, Helminthosporium maydis, Cercospora arachidicola, Uromyces phaseoli and Monilinia fructicola, Rhizoctonia solani, Pyricularia oryzae, Phytophthora infestans and other Phytophthora species. They also control seed pathogens such as Pythium aphanadermatum.

Disease control is ordinarily accomplished by applying an effective amount of the compound either pre- or post-infection to the portion of the plant to be protected, such as the roots, stems, foliage, fruit, seeds, tubers or bulbs, or to the media (soil or sand) in which the plants to be protected are growing. The compound may also be applied to the seed from which the plants to be protected are to be grown.

Rates of application for these compounds can be influenced by many factors of the environment and should be determined under actual use conditions. Foliage can normally be protected when treated at a rate of from less than 1 to 500 ppm of active ingredient. Plants growing in soil treated at a concentration from 0.1 to about 20 kg/ha can be protected from disease. Seed and seedlings can normally be protected when seed is treated at a rate of from 0.06 to about 3 grams per kilogram of seed.

The compounds of this invention can be mixed with fungicides, bactericides, acaricides, nematicides, insecticides, or other biologically active compounds in order to achieve desired results with a minimum expenditure of time, effort and material. Amounts of these biologically active materials added for each part by weight of the composition of this invention may vary from 0.05 to 25 parts by weight. Suitable agents of this type are well-known to those skilled in the art. Some are listed below:

Fungicides:

methyl 2-benzimidazolecarbamate (carbendazim)
tetramethylthiuram disulfide (thiuram)
n-dodecylguanidine acetate (dodine)
manganese ethylenebisdithiocarbamate (maneb)
1,4-dichloro-2,5-dimethoxybenzene (chloroneb)
methyl 1-(butylcarbamoyl)-2-benzimidazolecarbamate (benomyl)
2-cyano-N-ethylcarbamoyl-2-methoxyiminoacetamide (cymoxanil)
N-trichloromethylthiotetrahydrophthalimide (captan)
N-trichloromethylthiophthalimide (folpet)
dimethyl 4,4'-(o-phenylene)bis(3-thioallophanate) (thiophanate-methyl)
2-(thiazol-4-yl)benzimidazole (thiabendazole)
aluminum tris(O-ethyl phosphonate) ("Aliette")
tetrachloroisophthalonitrile (chlorothalonil)
2,6-dichloro-4-nitroaniline (dichloran)
N-(2,6-dimethylphenyl)-N-(methoxyacetyl)alanine methyl ester (metalaxyl)
cis-N-[(1,1,2,2-tetrachloroethyl)thio]cyclohex-4-ene-1,2-dicarbioximide (captafol)
3-(3,5-dichlorophenyl)-N-(1-methylethyl)-2,4-dioxo-1-imidazolidine carboxamide (iprodione)
3-(3,5-dichlorophenyl)-5-ethenyl-5-methyl-2,4-oxazolidinedione (vinclozolin)

kasugamycin

O-ethyl-S,S-diphenylphosphorodithioate (edifenphos)

Bactericides:

tribasic copper sulfate

streptomycin sulfate

oxytetracycline

Acaricides:

senecioic acid, ester with 2-sec-butyl-4,6-dinitrophenol (binapacryl)

6-methyl-1,3-dithiolo[2,3-B]quinonolin-2-one (oxythioquinox)

2,2,2-trichloro-1,1-bis(4-chlorophenyl)ethanol (dicofol)

bis(pentachloro-2,4-cyclopentadien-1-yl) (dienochlor)

tricyclohexyltin hydroxide (cyhexatin)

hexakis(2-methyl-2-phenylpropyl)distannoxane (fenbutin oxide)

Nematicides:

2-[diethoxyphosphinylimino]-1,3-dithietane (fosthietan)

S-methyl-1-(dimethylcarbamoyl)-N-(methylcarbamoyloxy)-thioformimidate (oxamyl)

S-methyl-1-carbamoyl-N-(methylcarbamoyloxy)thioformimidate

N-isopropylphosphoramidic acid, O-ethyl-O'-[4-(methylthio)-m-tolyl]diester (fenamiphos)

Insecticides:

3-hydroxy-N-methylcrotonamide(dimethylphosphate)ester (monocrotophos)

methylcarbamic acid, ester with 2,3-dihydro-2,2-dimethyl-7-benzofuranol (carbofuran)

O-[2,4,5-trichloro-α-(chloromethyl)benzyl]phosphoric acid, O',O'-dimethyl ester (tetrachlorvinphos)

2-mercaptosuccinic acid, diethyl ester, S-ester with thionophosphoric acid, dimethyl ester (malathion)

phosphorothioic acid, O,O-dimethyl, O-p-nitrophenyl ester (methyl parathion)

methylcarbamic acid, ester with α-naphthol (carbaryl)

methyl N-[[(methylamino)carbonyl]oxy]ethanimidothioate (methomyl)

N'-(4-chloro-o-tolyl)-N,N-dimethylformamidine (chlordimeform)

O,O-diethyl-O-(2-isopropyl-4-methyl-6-pyrimidyl)phosphorothioate (diazinon)

octachlorocamphene (toxaphene)

O-ethyl O-p-nitrophenyl phenylphosphonothioate (EPN)

cyano(3-phenoxyphenyl)-methyl 4-chloro-α-(1-methylethyl)benzeneacetate (fenvalerate)

(3-phenoxyphenyl)methyl (±)-cis,trans-3-(2,2-dichloroethenyl)-2,2-dimethylcyclopropanecarboxylate (permethrin)

dimethyl N,N'-[thiobis](N-methylimino)carbonyloxy]]-bis[ethanimidothioate] (thiodicarb)

phosphorothiolothionic acid, O-ethyl-O-[4-(methylthio)-phenyl]-S-n-propyl ester (sulprofos)

α-cyano-3-phenoxybenzyl 3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropane carboxylate (cypermethrin)

cyano(3-phenoxyphenyl)methyl 4-(difluoromethoxy)-α-(methylethyl)benzeneacetate ("Payoff")

O,O-diethyl-O-(3,5,6-trichloro-2-pyridyl)phosphorothioate (chlorpyrifos)

O,O-dimethyl-S-[(4-oxo-1,2,3-benzotriazin-3-(4H)-yl)-methyl]phosphorodithioate (azinphos-methyl)

5,6-dimethyl-2-dimethylamino-4-pyrimidinyl dimethyl carbamate ("Pirimor")

S-(N-formyl-N-methylcarbamoylmethyl)-O,O-dimethyl phosphorodithioate (formothion)

S-2-(ethylthioethyl)-O,O-dimethyl phosphiorothioate (demeton-S-methyl)

α-cyano-3-phenoxybenzyl cis-3-(2,2-dibromovinyl)-2,2-dimethylcyclopropane carboxylate (deltamethrin)

cyano(3-phenoxyphenyl)methyl ester of N-(2-chloro-4-trifluoromethylphenyl)alanine ("Mavrik")

This invention is further illustrated by the following examples.

Example 68

Compounds of this invention were dissolved in acetone in an amount equal to 6% of the final volume and then suspended at a concentration of 100 ppm in purified water containing 250 ppm of the surfactant TREM 014 (polyhydric alcohol esters). These suspensions were sprayed to the point of run-off on wheat seedlings. The following day, the plants were inoculated with a spore suspension of Puccinia recondita var. tritici, causal agent of wheat leaf rust, and incubated in a saturated humidity chamber at 20° for 24 hours and then in a growth room for an additional 7 days, when disease ratings were made. Percent disease control is shown in the following table. Treated plants had few or no rust pustules while the untreated plants had numerous rust pustules on each leaf.

Table 1

Compound	% Control Wheat Rust
(Dimethyl)phenyl(1,2,4-triazol-1-ylmethyl)silane	90
(4-Bromophenyl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	80
(1,1'-Biphenyl-4-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	100
(4-Chlorophenyl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	100
Butyl(4-chlorophenyl)methyl(1H-1,2,4-triazol-1-ylmethyl)silane	80
(3,4-Dichlorophenyl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	60

Table 1 (continued)

Compound	% Control Wheat Rust
(2,4-Dichlorophenyl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	90
bis(4-Chlorophenyl)(methyl)(1H-1,2,4-triazol-1-ylmethyl)silane	90
Dimethyl(4-fluorophenyl)(1H-1,2,4-triazol-1-ylmethyl)silane	100
[4-(1,1-Dimethylethyl)phenyl]dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	80[A]
Butyl(2,4-dichlorophenyl)methyl(1H-1,2,4-triazol-1-ylmethyl)silane	100
bis(2,4-Dichlorophenyl)(methyl)(1H-1,2,4-triazol-1-ylmethyl)silane	100
(2,4-Dichlorophenyl)methyl(phenyl)-(1H-1,2,4-triazol-1-ylmethyl)silane	100
(4-Chlorophenyl)methyl(phenyl)(1H-1,2,4-triazol-1-ylmethyl)silane	100
(4-Fluorophenyl)methyl(phenyl)(1H-1,2,4-triazol-1-ylmethyl)silane	90
Dodecyl(dimethyl)(1H-1,2,4-triazol-1-ylmethyl)silane	100[A]
[4-(4-Chlorophenoxy)phenyl]dimethyl-(1H-1,2,4-triazol-1-ylmethyl)silane	90
(3,5-Dichlorophenyl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	80
(1,1'-Biphenyl-4-yl)butyl(methyl)-(1H-1,2,4-triazol-1-ylmethyl)silane	90
bis(1,1'-Biphenyl-4-yl)(methyl)(1H-1,2,4-triazol-1-ylmethyl)silane	80
(1,1'-Biphenyl-4-yl)methyl(phenyl)-(1H-1,2,4-triazol-1-ylmethyl)silane	100
(1,1'-Biphenyl-3-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	80

Table 1 (continued)

Compound	% Control Wheat Rust
2-Chlorophenyl(methyl)phenyl(1H-1,2,4-triazol-1-ylmethyl)silane	80
[bis(2-Chlorophenyl)]methyl(1H-1,2,4-triazol-1-ylmethyl)silane	100
(1,1'-Biphenyl-4-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane, 4-dodecylbenzenesulfonic acid salt	100
(1,1'-Biphenyl-4-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane, 1:1 complex with zinc (II) chloride	100
(1,1'-Biphenyl-4-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane, 1:1 complex with manganous sulfate	90
2-Chlorophenyl(4-chlorophenyl)methyl-(1H-1,2,4-triazol-1-ylmethyl)silane	100
[bis(2-Fluorophenyl)]methyl(1H-1,2,4-triazol-1-ylmethyl)silane, 1:1 complex with cuprous chloride	90
[bis(2-Fluorophenyl)]methyl(1H-1,2,4-triazol-1-ylmethyl)silane, 2:1 complex with cupric chloride	100
(1,1'-Biphenyl-4-yl)dimethyl(1H-imidazol-1-ylmethyl)silane	100
(4-Chlorophenyl)(1H-imidazol-1-ylmethyl)dimethylsilane	50
Butyl(4-chlorophenyl)(1H-imidazol-1-ylmethyl)methylsilane	90
(1H-Imidazol-1-ylmethyl)dimethyl-(4-phenoxyphenyl)silane	60
Dimethyl(1H-imidazol-1-ylmethyl)-(4-methoxyphenyl)silane	60
(2,4-Dichlorophenyl)dimethyl(1H-imidazol-1-ylmethyl)silane	90

Table 1 (continued)

Compound	% Control Wheat Rust
bis(4-Fluorophenyl)(1H-imidazol-1-ylmethyl)methylsilane	100
Dimethyl(4-fluorophenyl)(1H-imidazol-1-ylmethyl)silane	80
Dimethyl(1H-imidazol-1-ylmethyl)-(4-trifluoromethylphenyl)silane	100[A]
Butyl(2,4-dichlorophenyl)(1H-imidazol-1-ylmethyl)methylsilane	100
bis(2,4-Dichlorophenyl)(1H-imidazol-1-ylmethyl)methylsilane	100
2,4-Dichlorophenyl(1H-imidazol-1-ylmethyl)methyl(phenyl)silane	90
4-Chlorophenyl(1H-imidazol-1-ylmethyl)methyl(phenyl)silane	100
Dodecyl(dimethyl)(1H-imidazol-1-ylmethyl)silane	80[A]
[4-(4-Chlorophenoxy)phenyl]dimethyl-(1H-imidazol-1-ylmethyl)silane	90
Butyl(1H-imidazol-1-ylmethyl)-methyl(phenyl)silane	90
(1,1'-Biphenyl-4-yl)butyl(1H-imidazol-1-ylmethyl)methylsilane	100
(1,1'-Biphenyl-4-yl)(1H-imidazol-1-ylmethyl)methyl(phenyl)silane	100
(1,1'-Biphenyl-3-yl)dimethyl(1H-imidazol-1-ylmethyl)silane	90
(4-Bromophenyl)(1H-imidazol-1-ylmethyl)methyl(phenyl)silane	90
(1,1'-Biphenyl-4-yl)dimethyl(1H-imidazol-1-ylmethyl)silane, 1:1 complex with cuprous chloride	100
(2-Chlorophenyl)(4-chlorophenyl)(1H-imidazol-1-ylmethyl)methylsilane	100

Table 1 (continued)

Compound	% Control Wheat Rust
(2-Chlorophenyl)(dimethyl)(1H-imidazol-1-ylmethyl)silane	80

A Compound applied at a concentration of 200 ppm.

Example 69

Compounds of this invention were dissolved in acetone in an amount equal to 6% of the final volume and then suspended at a concentration of 100 ppm in purified water containing 250 ppm of the surfactant TREM 014 (polyhydric alcohol esters). These suspensions were sprayed to the point of run-off on cucumber seedlings. The following day, the plants were inoculated with a spore suspension of the fungus Erysiphe cichoracearum, causal agent of cucumber powdery mildew, and incubated in a growth room for 7 days. Disease ratings were then made. Percent disease control is shown in the following table. Treated plants had little or no powdery mildew in contrast to untreated plants which were covered with powdery mildew. Phytotoxicity in the form of growth reduction or hormonal effects was observed on some of the plants in association with disease control.

Table 2

Compound	% Control Cucumber Powdery Mildew
(Dimethyl)phenyl(1,2,4-triazol-1-ylmethyl)silane	100
Ethyldimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	100
Butyldimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	100
Dimethyl(4-methylphenyl)(1H-1,2,4-triazol-1-ylmethyl)silane	100G[A]
(4-Bromophenyl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	100G

Table 2 (continued)

Compound	% Control Cucumber Powdery Mildew
(1,1'-Biphenyl-4-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	100
(4-Chlorophenyl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	100
Butyl(4-chlorophenyl)methyl(1H-1,2,4-triazol-1-ylmethyl)silane	100G
Dimethyl(1-naphthalenyl)(1H-1,2,4-triazol-1-ylmethyl)silane	100
(3,4-Dichlorophenyl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	100
Dimethyl(4-phenoxyphenyl)(1H-1,2,4-triazol-1-ylmethyl)silane	70
Dimethyl(4-methoxyphenyl)(1H-1,2,4-triazol-1-ylmethyl)silane	100
(2,4-Dichlorophenyl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	100H[B]
bis(4-Chlorophenyl)(methyl)(1H-1,2,4-triazol-1-ylmethyl)silane	100
(1H-1,2,4-Triazol-1-ylmethyl)triphenylsilane	100
Methyldiphenyl(1H-1,2,4-triazol-1-ylmethyl)silane	100G
(1,1'-Biphenyl-4-yl)dimethyl(4H-1,2,4-triazol-4-ylmethyl)silane	90
bis(4-Fluorophenyl)(methyl)(1H-1,2,4-triazol-1-ylmethyl)silane	100G
Dimethyl(4-fluorophenyl)(1H-1,2,4-triazol-1-ylmethyl)silane	100G
Dimethyl(4-methylthiophenyl)(1H-1,2,4-triazol-1-ylmethyl)silane	100

Table 2 (continued)

Compound	% Control Cucumber Powdery Mildew
Dimethyl(1H-1,2,4-triazol-1-ylmethyl)(4-trifluoromethylphenyl)-silane	100G
Dimethyl(1H-1,2,4-triazol-1-ylmethyl)(3-trifluoromethylphenyl)-silane	100
Dimethyl(1H-1,2,4-triazol-1-ylmethyl)(2-trifluoromethylphenyl)-silane	100
(2-Methoxyphenyl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	100G
Butyl(2,4-dichlorophenyl)methyl(1H-1,2,4-triazol-1-ylmethyl)silane	100G
bis(2,4-Dichlorophenyl)(methyl)(1H-1,2,4-triazol-1-ylmethyl)silane	100G
(2,4-Dichlorophenyl)methyl(phenyl)-(1H-1,2,4-triazol-1-ylmethyl)silane	100G
(4-Chlorophenyl)methyl(phenyl)(1H-1,2,4-triazol-1-ylmethyl)silane	100G
(4-Fluorophenyl)methyl(phenyl)(1H-1,2,4-triazol-1-ylmethyl)silane	100
Butyl(methyl)phenyl(1H-1,2,4-triazol-1-ylmethyl)silane	100
(2,3-Dimethoxyphenyl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	100G
(2,6-Dimethoxyphenyl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	100G
Dodecyl(dimethyl)(1H-1,2,4-triazol-1-ylmethyl)silane	60C
(2-Chlorophenyl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	100G
[4-(4-Chlorophenoxy)phenyl]dimethyl-(1H-1,2,4-triazol-1-ylmethyl)silane	80

Table 2 (continued)

Compound	% Control Cucumber Powdery Mildew
(1,1'-Biphenyl-4-yl)butyl(methyl)-(1H-1,2,4-triazol-1-ylmethyl)silane	100
Butyl(4-fluorophenyl)methyl(1H-1,2,4-triazol-1-ylmethyl)silane	100
bis(1,1'-Biphenyl-4-yl)(methyl)(1H-1,2,4-triazol-1-ylmethyl)silane	100
(1,1'-Biphenyl-4-yl)methyl(phenyl)-(1H-1,2,4-triazol-1-ylmethyl)silane	100
(1,1-Dimethylethoxy)methyl(phenyl)-(1H-1,2,4-triazol-1-ylmethyl)silane	100
Methyl(phenyl)(2-propoxy)(1H-1,2,4-triazol-1-ylmethyl)silane	100
(1,1'-Biphenyl-2-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	90
2-Chlorophenyl(methyl)phenyl(1H-1,2,4-triazol-1-ylmethyl)silane	100
4-Bromophenyl(methyl)phenyl(1H-1,2,4-triazol-1-ylmethyl)silane	100
[bis(2-Chlorophenyl)]methyl(1H-1,2,4-triazol-1-ylmethyl)silane	100
Cyclohexyl(dimethyl)(1H-1,2,4-triazol-1-ylmethyl)silane	100G
[bis(4-Bromophenyl)]methyl(1H-1,2,4-triazol-1-ylmethyl)silane	80G
(1,1'-Biphenyl-4-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane, 4-dodecyl-benzenesulfonic acid salt	100
(1,1'-Biphenyl-4-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane, 1:1 complex with cuprous chloride	100
(1,1'-Biphenyl-4-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane, 1:1 complex with zinc (II) chloride	80

Table 2 (continued)

Compound	% Control Cucumber Powdery Mildew
(1,1'-Biphenyl-4-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane, 1:1 complex with manganous sulfate	90
2-Chlorophenyl(4-chlorophenyl)methyl-(1H-1,2,4-triazol-1-ylmethyl)silane	100
Phenyl[bis(2-propoxy)](1H-1,2,4-triazol-1-ylmethyl)silane	100
[bis(2-Fluorophenyl)]methyl(1H-1,2,4-triazol-1-ylmethyl)silane, 1:1 complex with cuprous chloride	100
[bis(2-Fluorophenyl)]methyl(1H-1,2,4-triazol-1-ylmethyl)silane, 2:1 complex with cupric chloride	100
Dimethyl(1H-imidazol-1-ylmethyl)-phenylsilane	100
Ethyl(1H-imidazol-1-ylmethyl)-dimethylsilane	100
Butyl(1H-imidazol-1-ylmethyl)-dimethylsilane	100
(1H-Imidazol-1-ylmethyl)dimethyl-(4-methylphenyl)silane	100G[A]
(4-Bromophenyl)(1H-imidazol-1-ylmethyl)dimethylsilane	100
(1,1'-Biphenyl-4-yl)dimethyl(1H-imidazol-1-ylmethyl)silane	100
(4-Chlorophenyl)(1H-imidazol-1-ylmethyl)dimethylsilane	100
Butyl(4-chlorophenyl)(1H-imidazol-1-ylmethyl)methylsilane	100G
(1H-Imidazol-1-ylmethyl)dimethyl-(1-naphthalenyl)silane	100

Table 2 (continued)

Compound	% Control Cucumber Powdery Mildew
(3,4-Dichlorophenyl)(1H-imidazol-1-ylmethyl)dimethylsilane	100
(1H-Imidazol-1-ylmethyl)dimethyl-(4-phenoxyphenyl)silane	100
Dimethyl(1H-imidazol-1-ylmethyl)-(4-methoxyphenyl)silane	100
(2,4-Dichlorophenyl)dimethyl(1H-imidazol-1-ylmethyl)silane	100H[B]
bis(4-Chlorophenyl)(1H-imidazol-1-ylmethyl)methylsilane	100
(1H-Imidazol-1-ylmethyl)triphenylsilane	100
Diphenyl(1H-imidazol-1-ylmethyl)-methylsilane	100
bis(4-Fluorophenyl)(1H-imidazol-1-ylmethyl)methylsilane	100
Dimethyl(4-fluorophenyl)(1H-imidazol-1-ylmethyl)silane	100G
Dimethyl(1H-imidazol-1-ylmethyl)-(4-methylthiophenyl)silane	100
Dimethyl(1H-imidazol-1-ylmethyl)-(4-trifluoromethylphenyl)silane	100
Dimethyl(1H-imidazol-1-ylmethyl)-(3-trifluoromethylphenyl)silane	80
[4-(1,1-Dimethylethyl)phenyl](1H-imidazol-1-ylmethyl)dimethylsilane	80
(1H-Imidazol-1-ylmethyl)dimethyl-(2-trifluoromethylphenyl)silane	100G
Butyl(2,4-dichlorophenyl)(1H-imidazol-1-ylmethyl)methylsilane	100G

Table 2 (continued)

Compound	% Control Cucumber Powdery Mildew
bis(2,4-Dichlorophenyl)(1H-imidazol-1-ylmethyl)methylsilane	100
(2,4-Dichlorophenyl)(1H-imidazol-1-ylmethyl)methyl(phenyl)silane	100
(4-Chlorophenyl)(1H-imidazol-1-ylmethyl)methyl(phenyl)silane	100
(4-Fluorophenyl)(1H-imidazol-1-ylmethyl)methyl(phenyl)silane	100
(1H-Imidazol-1-ylmethyl)(2-methoxyphenyl)dimethylsilane	100G
(2,3-Dimethoxyphenyl)(1H-imidazol-1-ylmethyl)dimethylsilane	100
Dodecyl(dimethyl)(1H-imidazol-1-ylmethyl)silane	55
(2-Chlorophenyl)(1H-imidazol-1-ylmethyl)dimethylsilane	100
[4-(4-Chlorophenoxy)phenyl]dimethyl-(1H-imidazol-1-ylmethyl)silane	100
Butyl(1H-imidazol-1-ylmethyl)-methyl(phenyl)silane	100
(1,1'-Biphenyl-4-yl)butyl(1H-imidazol-1-ylmethyl)methylsilane	100
Butyl(4-fluorophenyl)(1H-imidazol-1-ylmethyl)methylsilane	100
Dibutyl(1H-imidazol-1-ylmethyl)-methylsilane	100
(1,1'-Biphenyl-4-yl)(1H-imidazol-1-ylmethyl)methyl(phenyl)silane	100
(1,1-Dimethylethoxy)(1H-imidazol-1-ylmethyl)methyl(phenyl)silane	100

Table 2 (continued)

Compound	% Control Cucumber Powdery Mildew
(1H-Imidazol-1-ylmethyl)methyl-(phenyl)(2-propoxy)silane	90
(1H-Imidazol-1-ylmethyl)[bis(4-methoxyphenyl)]methylsilane	50
(1,1'-Biphenyl-2-yl)dimethyl(1H-imidazol-1-ylmethyl)silane	50
(2-Chlorophenyl)(1H-imidazol-1-ylmethyl)methyl(phenyl)silane	100
(4-Bromophenyl)(1H-imidazol-1-ylmethyl)methyl(phenyl)silane	100
[bis(2-Chlorophenyl)](1H-imidazol-1-ylmethyl)methylsilane	100
Cyclohexyl(dimethyl(1H-imidazol-1-ylmethyl)silane	100G
[bis(4-Bromophenyl)](1H-imidazol-1-ylmethyl)methylsilane	100
(1,1'-Biphenyl-4-yl)dimethyl(1H-imidazol-1-ylmethyl)silane, 1:1 complex with cuprous chloride	100
(2-Chlorophenyl)(4-chlorophenyl)(1H-imidazol-1-ylmethyl)methylsilane	100
(2-Chlorophenyl)(dimethyl)(1H-imidazol-1-ylmethyl)silane	80

[A]G = growth reduction; and
[B]H = hormonal effects.

Example 70

Compounds of this invention were dissolved in acetone in an amount equal to 6% of the final volume and then suspended at a concentration of 100 ppm in purified water containing 250 ppm of the surfactant TREM 014 (polyhydric alcohol esters). These suspensions were sprayed to the point of run-off on barley seedlings. The following day, the plants were inoculated with a spore suspension of the fungus Erysiphe graminis, causal agent of barley powdery mildew, and incubated in a growth room for 7 days. Disease ratings were then made. Percent disease control is shown in the following table. Treated plants had little or no powdery mildew in contrast to untreated plants which were covered with powdery mildew.

Table 3

Compound	% Control Barley Powdery Mildew
Butyl(4-chlorophenyl)methyl(1H-1,2,4-triazol-1-ylmethyl)silane	90
(3,4-Dichlorophenyl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	100
Dimethyl(4-methoxyphenyl)(1H-1,2,4-triazol-1-ylmethyl)silane	100
(2,4-Dichlorophenyl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	100
bis(4-Chlorophenyl)(methyl)(1H-1,2,4-triazol-1-ylmethyl)silane	100
(1H-1,2,4-Triazol-1-ylmethyl)triphenylsilane	100
Methyldiphenyl(1H-1,2,4-triazol-1-ylmethyl)silane	100
Dimethyl(1H-1,2,4-triazol-1-ylmethyl)(2-trifluoromethylphenyl)-silane	100

Table 3 (continued)

Compound	% Control Barley Powdery Mildew
Dodecyl(dimethyl)(1H-1,2,4-triazol-1-ylmethyl)silane	100[A]
Butyl(4-chlorophenyl)(1H-imidazol-1-ylmethyl)methylsilane	100
(3,4-Dichlorophenyl)(1H-imidazol-1-ylmethyl)dimethylsilane	80
Dimethyl(1H-imidazol-1-ylmethyl)-(4-methoxyphenyl)silane	100
(2,4-Dichlorophenyl)dimethyl(1H-imidazol-1-ylmethyl)silane	100
bis(4-Chlorophenyl)(1H-imidazol-1-ylmethyl)methylsilane	100
Diphenyl(1H-imidazol-1-ylmethyl)-methylsilane	100
Dimethyl(1H-imidazol-1-ylmethyl)-(4-trifluoromethylphenyl)silane	100
Dodecyl(dimethyl)(1H-imidazol-1-ylmethyl)silane	100[A]

A Compound applied at a concentration of 200 ppm.

Example 71

Compounds of this invention were dissolved in acetone in an amount equal to 6% of the final volume and then suspended at a concentration of 100 ppm in purified water containing 250 ppm of the surfactant TREM 014 (polyhydric alcohol esters). These suspensions were sprayed to the point of run-off on apple seedlings. The following day, the plants were inoculated with a spore suspension of the fungus Venturia inaequalis, causal agent of apple scab, and incubated in a saturated humidity chamber at 20° for 24 hours and then in a growth room for an additional 10-12 days. Disease ratings were then made and recorded as shown in the following table. Treated plants had fewer apple scab lesions when compared to untreated plants which were covered with scab lesions. Phytotoxicity expressed as growth reduction was observed on some of the plants in association with disease control.

Table 4

Compound	% Control Apple Scab
Dimethyl(4-methylphenyl)(1H-1,2,4-triazol-1-ylmethyl)silane	50G[A]
(4-Bromophenyl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	90G
(1,1'-Biphenyl-4-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	100
(4-Chlorophenyl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	100
Butyl(4-chlorophenyl)methyl(1H-1,2,4-triazol-1-ylmethyl)silane	100G
Dimethyl(1-naphthalenyl)(1H-1,2,4-triazol-1-ylmethyl)silane	50

Table 4 (continued)

Compound	% Control Apple Scab
(3,4-Dichlorophenyl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	80
Dimethyl(4-phenoxyphenyl)(1H-1,2,4-triazol-1-ylmethyl)silane	100
Dimethyl(4-methoxyphenyl)(1H-1,2,4-triazol-1-ylmethyl)silane	100
(2,4-Dichlorophenyl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	100
bis(4-Chlorophenyl)(methyl)(1H-1,2,4-triazol-1-ylmethyl)silane	100
Methyldiphenyl(1H-1,2,4-triazol-1-ylmethyl)silane	100
(1,1'-Biphenyl-4-yl)dimethyl(4H-1,2,4-triazol-4-ylmethyl)silane	80
bis(4-Fluorophenyl)(methyl)(1H-1,2,4-triazol-1-ylmethyl)silane	100
Dimethyl(4-fluorophenyl)(1H-1,2,4-triazol-1-ylmethyl)silane	80C[B]
Dimethyl(4-methylthiophenyl)(1H-1,2,4-triazol-1-ylmethyl)silane	60
Dimethyl(1H-1,2,4-triazol-1-ylmethyl)-(2-trifluoromethylphenyl)silane	65G[A,C]
(2-Methoxyphenyl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	80
Butyl(2,4-dichlorophenyl)methyl(1H-1,2,4-triazol-1-ylmethyl)silane	100G
bis(2,4-Dichlorophenyl)(methyl)(1H-1,2,4-triazol-1-ylmethyl)silane	100
(2,4-Dichlorophenyl)methyl(phenyl)-(1H-1,2,4-triazol-1-ylmethyl)silane	100G
(4-Chlorophenyl)methyl(phenyl)(1H-1,2,4-triazol-1-ylmethyl)silane	100

Table 4 (continued)

Compound	% Control Apple Scab
(4-Fluorophenyl)methyl(phenyl)(1H-1,2,4-triazol-1-ylmethyl)silane	100
Butyl(methyl)phenyl(1H-1,2,4-triazol-1-ylmethyl)silane	80
Dodecyl(dimethyl)(1H-1,2,4-triazol-1-ylmethyl)silane	40[B,C,D]
(2-Chlorophenyl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	100
[4-(4-Chlorophenoxy)phenyl]dimethyl-(1H-1,2,4-triazol-1-ylmethyl)silane	100
(1,1'-Biphenyl-4-yl)butyl(methyl)-(1H-1,2,4-triazol-1-ylmethyl)silane	80
Butyl(4-fluorophenyl)methyl(1H-1,2,4-triazol-1-ylmethyl)silane	100
(1,1'-Biphenyl-4-yl)methyl(phenyl)-(1H-1,2,4-triazol-1-ylmethyl)silane	100
(1,1'-Biphenyl-2-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	60
(1,1'-Biphenyl-3-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	50
2-Chlorophenyl(methyl)phenyl(1H-1,2,4-triazol-1-ylmethyl)silane	90
4-Bromophenyl(methyl)phenyl(1H-1,2,4-triazol-1-ylmethyl)silane	100
[bis(2-Chlorophenyl)]methyl(1H-1,2,4-triazol-1-ylmethyl)silane	40
[bis(4-Bromophenyl)]methyl(1H-1,2,4-triazol-1-ylmethyl)silane	80
(1,1'-Biphenyl-4-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane, 4-dodecyl-benzenesulfonic acid salt	100

Table 4 (continued)

Compound	% Control Apple Scab
(1,1'-Biphenyl-4-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane, 1:1 complex with cuprous chloride	100
(1,1'-Biphenyl-4-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane, 1:1 complex with zinc (II) chloride	100
(1,1'-Biphenyl-4-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane, 1:1 complex with manganous sulfate	100
2-Chlorophenyl(4-chlorophenyl)methyl-(1H-1,2,4-triazol-1-ylmethyl)silane	90
2-Chlorophenyl(dimethyl)(1H-1,2,4-triazol-1-ylmethyl)silane	60
(1,1'-Biphenyl-4-yl)dimethyl(1H-imidazol-1-ylmethyl)silane	80
Butyl(4-chlorophenyl)(1H-imidazol-1-ylmethyl)methylsilane	90
(1H-Imidazol-1-ylmethyl)dimethyl-(1-naphthalenyl)silane	40
(3,4-Dichlorophenyl)(1H-imidazol-1-ylmethyl)dimethylsilane	80
(1H-Imidazol-1-ylmethyl)dimethyl-(4-phenoxyphenyl)silane	100
(2,4-Dichlorophenyl)dimethyl(1H-imidazol-1-ylmethyl)silane	100
Diphenyl(1H-imidazol-1-ylmethyl)-methylsilane	50
bis(4-Fluorophenyl)(1H-imidazol-1-ylmethyl)methylsilane	100
Dimethyl(1H-imidazol-1-ylmethyl)-(4-trifluoromethylphenyl)silane	60[C]
[4-(1,1-Dimethylethyl)phenyl](1H-imidazol-1-ylmethyl)dimethylsiiane	50

Table 4 (continued)

Compound	% Control Apple Scab
Butyl(2,4-dichlorophenyl)(1H-imidazol-1-ylmethyl)methylsilane	1008
bis(2,4-Dichlorophenyl)(1H-imidazol-1-ylmethyl)methylsilane	40
(2,4-Dichlorophenyl)(1H-imidazol-1-ylmethyl)methyl(phenyl)silane	80
(4-Chlorophenyl)(1H-imidazol-1-ylmethyl)methyl(phenyl)silane	100
(4-Fluorophenyl)(1H-imidazol-1-ylmethyl)methyl(phenyl)silane	100
(1H-Imidazol-1-ylmethyl)(2-methoxyphenyl)dimethylsilane	60
(2-Chlorophenyl)(1H-imidazol-1-ylmethyl)dimethylsilane	90
Butyl(1H-imidazol-1-ylmethyl)methyl(phenyl)silane	80
(1,1'-Biphenyl-4-yl)butyl(1H-imidazol-1-ylmethyl)methylsilane	100
Butyl(4-fluorophenyl)(1H-imidazol-1-ylmethyl)methylsilane	80
Dibutyl(1H-imidazol-1-ylmethyl)methylsilane	30
bis(1,1'-Biphenyl-4-yl)(1H-imidazol-1-ylmethyl)methylsilane	50
(1H-Imidazol-1-ylmethyl)[bis(4-methoxyphenyl)]methylsilane	50
(1,1'-Biphenyl-2-yl)dimethyl(1H-imidazol-1-ylmethyl)silane	90
(1,1'-Biphenyl-3-yl)dimethyl(1H-imidazol-1-ylmethyl)silane	90
(2-Chlorophenyl)(1H-imidazol-1-ylmethyl)methyl(phenyl)silane	100

Table 4 (continued)

Compound	% Control Apple Scab
(4-Bromophenyl)(1H-imidazol-1-ylmethyl)methyl(phenyl)silane	30
[bis(2-Chlorophenyl)](1H-imidazol-1-ylmethyl)methylsilane	60
Dimethyl(1H-imidazol-1-ylmethyl)-(4-methylsulfonylphenyl)silane	80
Cyclohexyl(dimethyl(1H-imidazol-1-ylmethyl)silane	100B
[bis(4-Bromophenyl)](1H-imidazol-1-ylmethyl)methylsilane	50
(1,1'-Biphenyl-4-yl)dimethyl(1H-imidazol-1-ylmethyl)silane, 1:1 complex with cuprous chloride	100
(2-Chlorophenyl)(4-chlorophenyl)(1H-imidazol-1-ylmethyl)methylsilane	80
(1H-Imidazol-1-ylmethyl)phenyl-[bis(2-propoxy)]silane	70
(2-Chlorophenyl)(dimethyl)(1H-imidazol-1-ylmethyl)silane	60

[A]G = growth reduction.
[B]C = chlorosis.
[C]compound applied at a concentration of 400 ppm.
[D]B = burn.

Example 72

Compounds of this invention were dissolved in acetone in an amount equal to 6% of the final volume and then suspended at a concentration of 100 ppm in purified water containing 250 ppm of the surfactant TREM 014 (polyhydric alcohol esters). These suspensions were sprayed to the point of run-off on corn seedlings. The following day, the plants were inoculated with a spore suspension of Helminthosporium maydis, causal agent of southern corn leaf blight, and incubated in a saturated humidity chamber at 20° for 24 hours and then in a growth room for an additional 7 days, when disease ratings were made. Percent disease control is shown in the following table. Treated plants had few or no lesions while the untreated plants had numerous lesions on each leaf. Phytotoxicity expressed as growth reduction was observed on some of the plants in association with disease control.

Table 5

Compound	% Control of Southern Corn Leaf Blight
(4-Bromophenyl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	90
(1,1'-Biphenyl-4-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	90
(3,4-Dichlorophenyl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	90
Dimethyl(4-methoxyphenyl)(1H-1,2,4-triazol-1-ylmethyl)silane	90
(2,4-Dichlorophenyl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	90
bis(4-Chlorophenyl)(methyl)(1H-1,2,4-triazol-1-ylmethyl)silane	80

Table 5 (continued)

Compound	% Control of Southern Corn Leaf Blight
Methyldiphenyl(1H-1,2,4-triazol-1-ylmethyl)silane	80
(1,1'-Biphenyl-4-yl)dimethyl(4H-1,2,4-triazol-4-ylmethyl)silane	100
bis(4-Fluorophenyl)(methyl)(1H-1,2,4-triazol-1-ylmethyl)silane	100
Dimethyl(4-fluorophenyl)(1H-1,2,4-triazol-1-ylmethyl)silane	90
Dimethyl(4-methylthiophenyl)(1H-1,2,4-triazol-1-ylmethyl)silane	80
Dimethyl(1H-1,2,4-triazol-1-ylmethyl)(4-trifluoromethylphenyl)-silane	50
[4-(1,1-Dimethylethyl)phenyl]dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	60
(2-Methoxyphenyl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	70
Butyl(2,4-dichlorophenyl)methyl(1H-1,2,4-triazol-1-ylmethyl)silane	100
bis(2,4-Dichlorophenyl)(methyl)(1H-1,2,4-triazol-1-ylmethyl)silane	80
(4-Chlorophenyl)methyl(phenyl)(1H-1,2,4-triazol-1-ylmethyl)silane	90
(4-Fluorophenyl)methyl(phenyl)(1H-1,2,4-triazol-1-ylmethyl)silane	90
(2-Chlorophenyl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	100
[4-(4-Chlorophenoxy)phenyl]dimethyl-(1H-1,2,4-triazol-1-ylmethyl)silane	50
(3,5-Dichlorophenyl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	40

Table 5 (continued)

Compound	% Control of Southern Corn Leaf Blight
(1,1'-Biphenyl-4-yl)butyl(methyl)-(1H-1,2,4-triazol-1-ylmethyl)silane	50
(1,1'-Biphenyl-4-yl)methyl(phenyl)-(1H-1,2,4-triazol-1-ylmethyl)silane	90
[bis(4-Methoxyphenyl)]methyl(1H-1,2,4-triazol-1-ylmethyl)silane	90
(1,1'-Biphenyl-2-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	90
(1,1'-Biphenyl-3-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	100
2-Chlorophenyl(methyl)phenyl(1H-1,2,4-triazol-1-ylmethyl)silane	100
4-Bromophenyl(methyl)phenyl(1H-1,2,4-triazol-1-ylmethyl)silane	80
[bis(2-Chlorophenyl)]methyl(1H-1,2,4-triazol-1-ylmethyl)silane	60
Cyclohexyl(dimethyl)(1H-1,2,4-triazol-1-ylmethyl)silane	50
(1,1'-Biphenyl-4-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane, 4-dodecylbenzenesulfonic acid salt	100
(1,1'-Biphenyl-4-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane, 1:1 complex with cuprous chloride	100
(1,1'-Biphenyl-4-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane, 1:1 complex with zinc (II) chloride	90
(1,1'-Biphenyl-4-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane, 1:1 complex with manganous sulfate	100
2-Chlorophenyl(4-chlorophenyl)methyl-(1H-1,2,4-triazol-1-ylmethyl)silane	60

Table 5 (continued)

Compound	% Control of Southern Corn Leaf Blight
(1,1'-Biphenyl-4-yl)dimethyl(1H-imidazol-1-ylmethyl)silane	90
Butyl(4-chlorophenyl)(1H-imidazol-1-ylmethyl)methylsilane	50
(3,4-Dichlorophenyl)(1H-imidazol-1-ylmethyl)dimethylsilane	70
(2,4-Dichlorophenyl)dimethyl(1H-imidazol-1-ylmethyl)silane	70
bis(4-Chlorophenyl)(1H-imidazol-1-ylmethyl)methylsilane	60
(1H-Imidazol-1-ylmethyl)triphenylsilane	50
Diphenyl(1H-imidazol-1-ylmethyl)-methylsilane	60
bis(4-Fluorophenyl)(1H-imidazol-1-ylmethyl)methylsilane	60
[4-(1,1-Dimethylethyl)phenyl](1H-imidazol-1-ylmethyl)dimethylsilane	70
(1H-Imidazol-1-ylmethyl)dimethyl-(2-trifluoromethylphenyl)silane	90
Butyl(2,4-dichlorophenyl)(1H-imidazol-1-ylmethyl)methylsilane	80
bis(2,4-Dichlorophenyl)(1H-imidazol-1-ylmethyl)methylsilane	80
(4-Fluorophenyl)(1H-imidazol-1-ylmethyl)methyl(phenyl)silane	80
(2,6-Dimethoxyphenyl)(dimethyl)(1H-imidazol-1-ylmethyl)silane	50
Dibutyl(1H-imidazol-1-ylmethyl)-methylsilane	90

Table 5 (continued)

Compound	% Control of Southern Corn Leaf Blight
(1,1'-Biphenyl-4-yl)(1H-imidazol-1-ylmethyl)methyl(phenyl)silane	80
(1,1'-Biphenyl-3-yl)dimethyl(1H-imidazol-1-ylmethyl)silane	90
[bis(2-Chlorophenyl)](1H-imidazol-1-ylmethyl)methylsilane	90
Cyclohexyl(dimethyl(1H-imidazol-1-ylmethyl)silane	50

Example 73

Compounds of this invention were dissolved in acetone in an amount equal to 6% of the final volume and then suspended at a concentration of 100 ppm in purified water containing 250 ppm of the surfactant TREM 014 (polyhydric alcohol esters). These suspensions were sprayed to the point of run-off on peanut seedlings. The following day, the plants were inoculated with a spore suspension of Cercospora arachidicola, causal agent of peanut early leafspot, and incubated in a saturated humidity chamber at 27° for 24 hours and then in a growth room for an additional 14 days, when disease ratings were made. The results are shown in the following table. Treated plants had few or no leafspots while the untreated plants had numerous leafspots. Phytotoxicity expressed as burn was observed in association with disease control for some treated plants.

Table 6

Compound	% Control Peanut Early Leafspot
bis(4-Chlorophenyl)(methyl)(1H-1,2,4-triazol-1-ylmethyl)silane	100
Methyldiphenyl(1H-1,2,4-triazol-1-ylmethyl)silane	100
(1,1'-Biphenyl-4-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	100
(4-Chlorophenyl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	90
Dimethyl(1-naphthalenyl)(1H-1,2,4-triazol-1-ylmethyl)silane	90
(2,4-Dichlorophenyl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	100

Table 6 (continued)

Compound	% Control Peanut Early Leafspot
bis(4-Fluorophenyl)(methyl)(1H-1,2,4-triazol-1-ylmethyl)silane	100
Dimethyl(4-fluorophenyl)(1H-1,2,4-triazol-1-ylmethyl)silane	50
[4-(1,1-Dimethylethyl)phenyl]dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	35
Dimethyl(1H-1,2,4-triazol-1-ylmethyl)(2-trifluoromethylphenyl)-silane	25B
Butyl(2,4-dichlorophenyl)methyl(1H-1,2,4-triazol-1-ylmethyl)silane	100
bis(2,4-Dichlorophenyl)(methyl)(1H-1,2,4-triazol-1-ylmethyl)silane	100
(2,4-Dichlorophenyl)methyl(phenyl)-(1H-1,2,4-triazol-1-ylmethyl)silane	100
(4-Chlorophenyl)methyl(phenyl)(1H-1,2,4-triazol-1-ylmethyl)silane	100
(4-Fluorophenyl)methyl(phenyl)(1H-1,2,4-triazol-1-ylmethyl)silane	100
(2-Chlorophenyl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	30
(1,1'-Biphenyl-4-yl)butyl(methyl)-(1H-1,2,4-triazol-1-ylmethyl)silane	100
bis(1,1'-Biphenyl-4-yl)(methyl)(1H-1,2,4-triazol-1-ylmethyl)silane	80
(1,1'-Biphenyl-4-yl)methyl(phenyl)-(1H-1,2,4-triazol-1-ylmethyl)silane	100
[bis(4-Methoxyphenyl)]methyl(1H-1,2,4-triazol-1-ylmethyl)silane	30
(1,1'-Biphenyl-2-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	100

Table 6 (continued)

Compound	% Control Peanut Early Leafspot
(1,1'-Biphenyl-3-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	90
2-Chlorophenyl(methyl)phenyl(1H-1,2,4-triazol-1-ylmethyl)silane	100
4-Bromophenyl(methyl)phenyl(1H-1,2,4-triazol-1-ylmethyl)silane	100
[bis(2-Chlorophenyl)]methyl(1H-1,2,4-triazol-1-ylmethyl)silane	100
[bis(4-Bromophenyl)]methyl(1H-1,2,4-triazol-1-ylmethyl)silane	100
(1,1'-Biphenyl-4-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane, 4-dodecylbenzenesulfonic acid salt	100
(1,1'-Biphenyl-4-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane, 1:1 complex with cuprous chloride	100
(1,1'-Biphenyl-4-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane, 1:1 complex with zinc (II) chloride	100
(1,1'-Biphenyl-4-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane, 1:1 complex with manganous sulfate	100
2-Chlorophenyl(4-chlorophenyl)methyl-(1H-1,2,4-triazol-1-ylmethyl)silane	90
[bis(2-Fluorophenyl)]methyl(1H-1,2,4-triazol-1-ylmethyl)silane, 1:1 complex with cuprous chloride	100
[bis(2-Fluorophenyl)]methyl(1H-1,2,4-triazol-1-ylmethyl)silane, 2:1 complex with cupric chloride	100
(1,1'-Biphenyl-4-yl)dimethyl(1H-imidazol-1-ylmethyl)silane	100

Table 6 (continued)

Compound	% Control Peanut Early Leafspot
(2,4-Dichlorophenyl)dimethyl(1H-imidazol-1-ylmethyl)silane	100
Diphenyl(1H-imidazol-1-ylmethyl)-methylsilane	50
bis(4-Fluorophenyl)(1H-imidazol-1-ylmethyl)methylsilane	100
Dimethyl(4-fluorophenyl)(1H-imidazol-1-ylmethyl)silane	608[A]
Dimethyl(1H-imidazol-1-ylmethyl)-(4-trifluoromethylphenyl)silane	36[B]
Dimethyl(1H-imidazol-1-ylmethyl)-(3-trifluoromethylphenyl)silane	50
Butyl(2,4-dichlorophenyl)(1H-imidazol-1-ylmethyl)methylsilane	100
bis(2,4-Dichlorophenyl)(1H-imidazol-1-ylmethyl)methylsilane	90
(2,4-Dichlorophenyl)(1H-imidazol-1-ylmethyl)methyl(phenyl)silane	100
(4-Chlorophenyl)(1H-imidazol-1-ylmethyl)methyl(phenyl)silane	100
(4-Fluorophenyl)(1H-imidazol-1-ylmethyl)methyl(phenyl)silane	100
(2-Chlorophenyl)(1H-imidazol-1-ylmethyl)dimethylsilane	80
(1,1'-Biphenyl-4-yl)butyl(1H-imidazol-1-ylmethyl)methylsilane	90
bis(1,1'-Biphenyl-4-yl)(1H-imidazol-1-ylmethyl)methylsilane	60
(1,1'-Biphenyl-4-yl)(1H-imidazol-1-ylmethyl)methyl(phenyl)-silane	80

Table 6 (continued)

Compound	% Control Pe Early Leafs
(1,1'-Biphenyl-2-yl)dimethyl(1H-imidazol-1-ylmethyl)silane	30
(1,1'-Biphenyl-3-yl)dimethyl(1H-imidazol-1-ylmethyl)silane	80
(2-Chlorophenyl)(1H-imidazol-1-ylmethyl)methyl(phenyl)silane	100
(4-Bromophenyl)(1H-imidazol-1-ylmethyl)methyl(phenyl)silane	90
[bis(2-Chlorophenyl)](1H-imidazol-1-ylmethyl)methylsilane	100
[bis(4-Bromophenyl)](1H-imidazol-1-ylmethyl)methylsilane	50
(1,1'-Biphenyl-4-yl)dimethyl(1H-imidazol-1-ylmethyl)silane, 1:1 complex with cuprous chloride	100
(2-Chlorophenyl)(4-chlorophenyl)(1H-imidazol-1-ylmethyl)methylsilane	80

[A]B = Phytotoxic burn.
[B]Compound applied at a concentration of 400 ppm.

Example 74

Compounds of this invention were dissolved in acetone in an amount equal to 6% of the final volume and then suspended at a concentration of 80 ppm in purified water containing 250 ppm of the surfactant TREM 014 (polyhydric alcohol esters). This suspension was sprayed to the point of run-off on bean seedlings. The following day, the plants were inoculated with a spore suspension of the fungus Uromyces phaseoli, causal agent of bean rust, and incubated in a saturated humidity chamber at 20° for 24 hours and then in a greenhouse for 7 days. Disease ratings were then made. Percent disease control is shown in the following table. Treated plants had few or no rust pustules in contrast to untreated plants which were covered with rust pustules. Phytotoxicity in the form of growth reduction was observed in association with disease control for some treated plants.

Table 7

Compound	% Control Bean Rust
(1,1'-Biphenyl-4-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	100
(2,4-Dichlorophenyl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	30G[A]
bis(4-Chlorophenyl)(methyl)(1H-1,2,4-triazol-1-ylmethyl)silane	100G
(4-Chlorophenyl)methyl(phenyl)(1H-1,2,4-triazol-1-ylmethyl)silane	98[B]
(4-Fluorophenyl)methyl(phenyl)(1H-1,2,4-triazol-1-ylmethyl)silane	100[B]
bis(4-Fluorophenyl)(methyl)(1H-1,2,4-triazol-1-ylmethyl)silane	98[B]
(1,1'-Biphenyl-4-yl)dimethyl(1H-imidazol-1-ylmethyl)silane	100

Table 7 (continued)

Compound	% Control Bean Rust
(2,4-Dichlorophenyl)dimethyl(1H-imidazol-1-ylmethyl)silane	83

[A]G = growth reduction.
[B]compound applied at a concentration of 16 ppm.

Example 75

Compounds of this invention were dissolved in acetone in an amount equal to 5% of the final volume and then suspended at a concentration of 100 ppm in purified water containing 700 ppm of the surfactant TREM 014 (polyhydric alcohol esters). Canned peach halves were dipped in this suspension for three minutes and then placed to air dry in sterile containers. Upon drying, the peach halves were inoculated with two pieces of Monilinia fructicola mycelium, causal agent of stone fruit brown rot, and incubated in the sterile containers for five days. At that time the radii of the colonies' growth were measured on each peach. Colonies on treated peaches did not grow or grew only a few milliliters in diameter while those growing on untreated peaches covered the entire surface of the peach. Percent disease contol (percent growth inhibition of colonies on treated peaches as compared to that of colonies on untreated peaches) is expressed in the table below.

Table 8

Compound	% Control Brown Rot
(Dimethyl)phenyl(1,2,4-triazol-1-ylmethyl)silane	89
(Butyl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	95
(1,1'-Biphenyl-4-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	100
Butyl(4-chlorophenyl)methyl(1H-1,2,4-triazol-1-ylmethyl)silane	98
Dimethyl(4-methoxyphenyl)(1H-1,2,4-triazol-1-ylmethyl)silane	97

Table 8 (continued)

Compound	% Control Brown Rot
(2,4-Dichlorophenyl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	100
bis(4-Chlorophenyl)(methyl)(1H-1,2,4-triazol-1-ylmethyl)silane	95
(1,1'-Biphenyl-4-yl)dimethyl(4H-1,2,4-triazol-4-ylmethyl)silane	96
bis(4-Fluorophenyl)(methyl)(1H-1,2,4-triazol-1-ylmethyl)silane	100
Butyl(2,4-dichlorophenyl)methyl(1H-1,2,4-triazol-1-ylmethyl)silane	98
(4-Chlorophenyl)methyl(phenyl)(1H-1,2,4-triazol-1-ylmethyl)silane	70
(4-Fluorophenyl)methyl(phenyl)(1H-1,2,4-triazol-1-ylmethyl)silane	90
Butyl(4-fluorophenyl)methyl(1H-1,2,4-triazol-1-ylmethyl)silane	100
Dibutyl(methyl)(1H-1,2,4-triazol-1-ylmethyl)silane	81
(1,1'-Biphenyl-4-yl)dimethyl(1H-imidazol-1-ylmethyl)silane	83
Butyl(4-chlorophenyl)(1H-imidazol-1-ylmethyl)methylsilane	45
(1H-Imidazol-1-ylmethyl)dimethyl-(4-phenoxyphenyl)silane	80
(2,4-Dichlorophenyl)dimethyl(1H-imidazol-1-ylmethyl)silane	100
Diphenyl(1H-imidazol-1-ylmethyl)-methylsilane	76
(4-Chlorophenyl)(1H-imidazol-1-ylmethyl)methyl(phenyl)silane	45
(4-Fluorophenyl)(1H-imidazol-1-ylmethyl)methyl(phenyl)silane	65

Example 76

Compounds of this invention were dissolved in acetone in an amount equal to 6% of the final volume and then suspended at a concentration of 100 ppm in purified water containing 250 ppm of the surfactant TREM 014 (polyhydric alcohol esters). This suspension was sprayed to the point of run-off on rice seedlings. The following day, the plants were inoculated with a mixture of bran and the mycelium of Rhizoctonia solani, causal agent of sheath blight of rice, and incubated in a growth room for 7 days. Disease ratings were then made. Percent disease control is shown in the following table. Treated plants had little sheath blight in contrast to untreated plants which were covered with sheath blight.

Table 9

Compound	% Control of Rice Sheath Blight
(1,1'-Biphenyl-4-yl)dimethyl-(1H-1,2,4-triazol-1-ylmethyl)-silane	40
(3,4-Dichlorophenyl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	80
bis(4-Fluorophenyl)(methyl)(1H-1,2,4-triazol-1-ylmethyl)silane	80
[4-(1,1-Dimethylethyl)phenyl]dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	90
Butyl(2,4-dichlorophenyl)methyl(1H-1,2,4-triazol-1-ylmethyl)silane	50
(4-Chlorophenyl)methyl(phenyl)(1H-1,2,4-triazol-1-ylmethyl)silane	90
(4-Fluorophenyl)methyl(phenyl)(1H-1,2,4-triazol-1-ylmethyl)silane	80

Table 9 (continued)

Compound	% Control of Rice Sheath Blight
Butyl(methyl)phenyl(1H-1,2,4-triazol-1-ylmethyl)silane	90
(1,1'-Biphenyl-4-yl)butyl(methyl)-(1H-1,2,4-triazol-1-ylmethyl)silane	80
Butyl(4-fluorophenyl)methyl(1H-1,2,4-triazol-1-ylmethyl)silane	80
bis(1,1'-Biphenyl-4-yl)(methyl)(1H-1,2,4-triazol-1-ylmethyl)silane	90
[bis(4-Methoxyphenyl)]methyl(1H-1,2,4-triazol-1-ylmethyl)silane	80
2-Chlorophenyl(methyl)phenyl(1H-1,2,4-triazol-1-ylmethyl)silane	90
4-Bromophenyl(methyl)phenyl(1H-1,2,4-triazol-1-ylmethyl)silane	90
[bis(2-Chlorophenyl)]methyl(1H-1,2,4-triazol-1-ylmethyl)silane	60
(1,1'-Biphenyl-4-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane, 1:1 complex with cuprous chloride	90
(1,1'-Biphenyl-4-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane, 1:1 complex with zinc (II) chloride	90
2-Chlorophenyl(4-chlorophenyl)methyl-(1H-1,2,4-triazol-1-ylmethyl)silane	70
[bis(2-Fluorophenyl)]methyl(1H-1,2,4-triazol-1-ylmethyl)silane, 1:1 complex with cuprous chloride	90
(1H-Imidazol-1-ylmethyl)dimethyl-(4-phenoxyphenyl)silane	70
bis(4-Fluorophenyl)(1H-imidazol-1-ylmethyl)methylsilane	90

Table 9 (continued)

Compound	% Control of Rice Sheath Blight
(1H-Imidazol-1-ylmethyl)dimethyl-(2-trifluoromethylphenyl)silane	80
Butyl(2,4-dichlorophenyl)(1H-imidazol-1-ylmethyl)methylsilane	90
bis(2,4-Dichlorophenyl)(1H-imidazol-1-ylmethyl)methylsilane	80
(4-Fluorophenyl)(1H-imidazol-1-ylmethyl)methyl(phenyl)silane	90
(1H-Imidazol-1-ylmethyl)(2-methoxyphenyl)dimethylsilane	90
[4-(4-Chlorophenoxy)phenyl]dimethyl-(1H-imidazol-1-ylmethyl)silane	70
Butyl(1H-imidazol-1-ylmethyl)-methyl(phenyl)silane	80
(1,1'-Biphenyl-4-yl)butyl(1H-imidazol-1-ylmethyl)methylsilane	90
Butyl(4-fluorophenyl)(1H-imidazol-1-ylmethyl)methylsilane	80
(1,1'-Biphenyl-2-yl)dimethyl(1H-imidazol-1-ylmethyl)silane	90
(1,1'-Biphenyl-3-yl)dimethyl(1H-imidazol-1-ylmethyl)silane	90
[bis(2-Chlorophenyl)](1H-imidazol-1-ylmethyl)methylsilane	40
(1,1'-Biphenyl-4-yl)dimethyl(1H-imidazol-1-ylmethyl)silane, 1:1 complex with cuprous chloride	50
(2-Chlorophenyl)(dimethyl)(1H-imidazol-1-ylmethyl)silane	90

Example 77

Compounds of this invention were dissolved in acetone in an amount equal to 6% of the final volume and then suspended at a concentration of 100 ppm in purified water containing 250 ppm of the surfactant TREM 014 (polyhydric alcohol esters). These suspensions were sprayed to the point of run-off on rice seedlings. The following day, the plants were inoculated with a spore suspension of Pyricularia oryzae, causal agent of rice blast, and incubated in a saturated humidity chamber at 28°C for 24 hours and then in a growth room for an additional 7 days, when disease ratings were made. Percent disease control is shown in the following table. Treated plants had no or few lesions while the untreated plants had numerous lesions on each leaf.

Table 10

Compound	% Control of Rice Blast
Dimethyl(1-naphthalenyl)(1H-1,2,4-triazol-1-ylmethyl)silane	70
bis(4-Chlorophenyl)(methyl)(1H-1,2,4-triazol-1-ylmethyl)silane	90
bis(4-Fluorophenyl)(methyl)(1H-1,2,4-triazol-1-ylmethyl)silane	100
[4-(1,1-Dimethylethyl)phenyl]dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	90
(4-Chlorophenyl)methyl(phenyl)(1H-1,2,4-triazol-1-ylmethyl)silane	100
Butyl(methyl)phenyl(1H-1,2,4-triazol-1-ylmethyl)silane	90
(2-Chlorophenyl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	100

Table 10 (continued)

Compound	% Control of Rice Blast
(1,1'-Biphenyl-4-yl)butyl(methyl)-(1H-1,2,4-triazol-1-ylmethyl)silane	100
Butyl(4-fluorophenyl)methyl(1H-1,2,4-triazol-1-ylmethyl)silane	100
Dibutyl(methyl)(1H-1,2,4-triazol-1-ylmethyl)silane	80
bis(1,1'-Biphenyl-4-yl)(methyl)(1H-1,2,4-triazol-1-ylmethyl)silane	100
(1,1'-Biphenyl-2-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	90
2-Chlorophenyl(methyl)phenyl(1H-1,2,4-triazol-1-ylmethyl)silane	100
4-Bromophenyl(methyl)phenyl(1H-1,2,4-triazol-1-ylmethyl)silane	80
[bis(2-Chlorophenyl)]methyl(1H-1,2,4-triazol-1-ylmethyl)silane	90
Dimethyl(4-methylsulfonylphenyl)(1H-1,2,4-triazol-1-ylmethyl)silane	70
[bis(4-Bromophenyl)]methyl(1H-1,2,4-triazol-1-ylmethyl)silane	90
(1,1'-Biphenyl-4-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane, 4-dodecylbenzenesulfonic acid salt	80
(1,1'-Biphenyl-4-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane, 1:1 complex with cuprous chloride	100
(1,1'-Biphenyl-4-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane, 1:1 complex with zinc (II) chloride	100
[bis(2-Fluorophenyl)]methyl(1H-1,2,4-triazol-1-ylmethyl)silane, 1:1 complex with cuprous chloride	90

Table 10 (continued)

Compound	% Control of Rice Blast
[bis(2-Fluorophenyl)]methyl(1H-1,2,4-triazol-1-ylmethyl)silane, 2:1 complex with cupric chloride	100
(1H-Imidazol-1-ylmethyl)dimethyl-(4-phenoxyphenyl)silane	70
[4-(1,1-Dimethylethyl)phenyl](1H-imidazol-1-ylmethyl)dimethylsilane	80
(4-Fluorophenyl)(1H-imidazol-1-ylmethyl)methyl(phenyl)silane	100
[4-(4-Chlorophenoxy)phenyl]dimethyl-(1H-imidazol-1-ylmethyl)silane	100
Butyl(1H-imidazol-1-ylmethyl)-methyl(phenyl)silane	90
(1,1'-Biphenyl-4-yl)butyl(1H-imidazol-1-ylmethyl)methylsilane	90
Butyl(4-fluorophenyl)(1H-imidazol-1-ylmethyl)methylsilane	100
(1,1'-Biphenyl-2-yl)dimethyl(1H-imidazol-1-ylmethyl)silane	90
(1,1'-Biphenyl-3-yl)dimethyl(1H-imidazol-1-ylmethyl)silane	80
[bis(2-Chlorophenyl)](1H-imidazol-1-ylmethyl)methylsilane	90
Dimethyl(1H-imidazol-1-ylmethyl)-(4-methylsulfonylphenyl)silane	100
[bis(4-Bromophenyl)](1H-imidazol-1-ylmethyl)methylsilane	80

Example 78

Compounds of this invention were dissolved in acetone in an amount equal to 6% of the final volume and then suspended at a concentration of 100 ppm in purified water containing 250 ppm of the surfactant TREM 014 (polyhydric alcohol esters). These suspensions were sprayed to the point of run-off on tomato seedlings. The following day, the plants were inoculated with a spore suspension of Phytophthora infestans, causal agent of tomato late blight, and incubated in a saturated humidity chamber at 20°C for 24 hours and then in a growth room for an additional 7 days, when disease ratings were made. Percent disease control is shown in the following table. Treated plants had no or few lesions while the untreated plants had numerous lesions on each leaf.

Table 11

Compound	% Control of Tomato Late Blight
Dimethyl(4-phenoxyphenyl)(1H-1,2,4-triazol-1-ylmethyl)silane	50
[4-(4-Chlorophenoxy)phenyl]dimethyl-(1H-1,2,4-triazol-1-ylmethyl)silane	50
(1,1'-Biphenyl-2-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	50
(1,1'-Biphenyl-4-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane, 4-dodecyl-benzenesulfonic acid salt	60
(1,1'-Biphenyl-4-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane, 1:1 complex with cuprous chloride	100
(1,1'-Biphenyl-4-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane, 1:1 complex with zinc (II) chloride	90

Table 11 (continued)

Compound	% Control of Tomato Late Blight
[bis(2-Fluorophenyl)]methyl(1H-1,2,4-triazol-1-ylmethyl)silane, 2:1 complex with cupric chloride	40
(4-Bromophenyl)(1H-imidazol-1-ylmethyl)dimethylsilane	30
(1,1'-Biphenyl-4-yl)dimethyl(1H-imidazol-1-ylmethyl)silane	50
(1H-Imidazol-1-ylmethyl)dimethyl-(4-phenoxyphenyl)silane	80
Dimethyl(1H-imidazol-1-ylmethyl)-(3-trifluoromethylphenyl)silane	70
(2,6-Dimethoxyphenyl)(dimethyl)(1H-imidazol-1-ylmethyl)silane	50
[bis(2-Chlorophenyl)](1H-imidazol-1-ylmethyl)methylsilane	60

Example 79

Compounds of this invention were incorporated into 45°C standard strength V-8 agar at a concentration of 200.0 ppm. The amended media were then dispensed into petri dishes and allowed to solidify. Plugs approximately 4 mm^2 from agar cultures of 5 Phytophthora species: Phytophthora cinnamomi, P. cactorum, P. infestans, P. palmivora, and P. parasitica var. nicotianae were placed on the media and incubated at 22°C for 6 days. Colonies whose radial growth extended 1 mm or less were considered to be controlled by a compound when compared to colonies whose radial growth extended 15 mm or more when growing on unamended media. The number of Phytophthora species controlled by certain compounds of this invention are listed in the table below.

Table 12

Compound	# of 5 Phytophthora species controlled in vitro
(Butyl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	1
(3,4-Dichlorophenyl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	2
(1,1'-Biphenyl-4-yl)dimethyl(1H-imidazol-1-ylmethyl)silane	3
(1H-Imidazol-1-ylmethyl)dimethyl-(4-phenoxyphenyl)silane	4
(2,4-Dichlorophenyl)dimethyl(1H-imidazol-1-ylmethyl)silane	5
Diphenyl(1H-imidazol-1-ylmethyl)-methylsilane	2
(4-Fluorophenyl)(1H-imidazol-1-ylmethyl)methyl(phenyl)silane	2

Example 80

Compounds of this invention were incorporated into a proprietary formulation and used to coat cotton seeds at a rate of 2 gm/kg seed. After being thoroughly coated, the seeds were allowed to air dry at room temperature. The cotton seeds were then planted into soil amended with the fungus Pythium aphanadermatum, sand, and corn meal at a rate sufficient to kill most untreated seeds. The seeds were held at room temperature for 1 week, after which time disease ratings were made. Percent disease control is shown in the following table. Most or all seeds from treatments germinated and produced vigorous seedlings in contrast to untreated seeds which either did not germinate or produced damped off or weak seedlings.

Table 13

Compound	% Control of Pythium on Cotton
Ethyldimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	48
(1,1'-Biphenyl-4-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	12
(4-Chlorophenyl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	53[A]
Dimethyl(4-phenoxyphenyl)(1H-1,2,4-triazol-1-ylmethyl)silane	18[A]
(1,1'-Biphenyl-4-yl)dimethyl(1H-imidazol-1-ylmethyl)silane	18
(4-Chlorophenyl)(1H-imidazol-1-ylmethyl)dimethylsilane	18[A]
(3,4-Dichlorophenyl)(1H-imidazol-1-ylmethyl)dimethylsilane	15[A]

[A]control at a rate of 0.5 gm/kg seed.

Example 81

Compounds of this invention were incorporated into a proprietary formulation and used to coat corn seeds at a rate of 2 gm/kg seed. After being thoroughly coated, the seeds were allowed to air dry at room temperature. The seeds were then planted into soil amended with a mixture of the fungus Pythium aphanadermatum, sand, and corn meal at a rate sufficient to kill most untreated seeds. The seeds were held at 49°F for 2 weeks and then at 70°F for 1 additional week. After this time disease ratings were made. Percent disease control is shown in the following table. Most or all seeds from treatments germinated and produced vigorous seedlings in contrast to untreated seeds which either did not germinate or produced damped off or weak seedlings.

Table 14

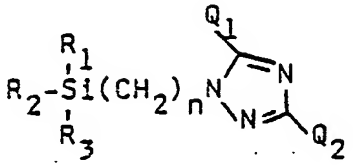
Compound	% Control of Pythium on Corn
Ethyldimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	13
(1,1'-Biphenyl-4-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	30
(4-Chlorophenyl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	8
Dimethyl(1-naphthalenyl)(1H-1,2,4-triazol-1-ylmethyl)silane	30
(3,4-Dichlorophenyl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)silane	43
Ethyl(1H-imidazol-1-ylmethyl)-dimethylsilane	70
(1H-Imidazol-1-ylmethyl)dimethyl-(4-methylphenyl)silane	30

Table 14 (continued)

Compound	% Control of Pythium on Corn
(1,1'-Biphenyl-4-yl)dimethyl(1H-imidazol-1-ylmethyl)silane	32
(4-Chlorophenyl)(1H-imidazol-1-ylmethyl)dimethylsilane	25
(1H-Imidazol-1-ylmethyl)dimethyl-(1-naphthalenyl)silane	27
(3,4-Dichlorophenyl)(1H-imidazol-1-ylmethyl)dimethylsilane	30
(1H-Imidazol-1-ylmethyl)dimethyl-(4-phenoxyphenyl)silane	5
Dimethyl(4-fluorophenyl)(1H-imidazol-1-ylmethyl)silane	15

Claims:

1. A compound of the formula:



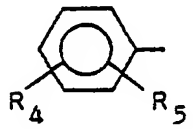
I

wherein

Q_1 and Q_2 are independently H or CH_3;

n is 1;

R_1 is C_2-C_{18} alkyl, C_3-C_6 cycloalkyl, naphthyl, or

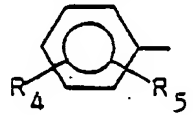


;

where

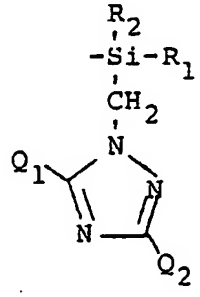
R_4 and R_5 are independently -H; halogen; $-OCH_3$; $-OCF_3$; $-SCH_3$; $-SO_2CH_3$; phenyl; phenyl substituted with halogen and/or C_1-C_4 alkyl and/or $-CF_3$; phenoxy; phenoxy substituted with halogen and/or C_1-C_4 alkyl and/or $-CF_3$; $-CF_3$; C_1-C_4 alkyl; or cyclohexyl;

R_2 and R_3 are independently C_1-C_6 alkyl, C_3-C_6 cycloalkyl, OR_6, or

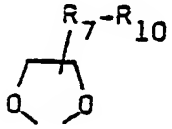


;

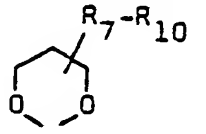
where R_6 is H or C_1-C_4 alkyl, or one R_6 group may be



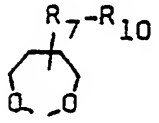
with the proviso that both R_2 and R_3 may not be OH; and R_2 and R_3 together may be a 1,2- or 1,3- or 1,4-glycol bridge or a 1,4 unsaturated glycol bridge which may optionally be substituted by up to four alkyl groups R_7-R_{10} that have a total of up to four carbon atoms, viz.



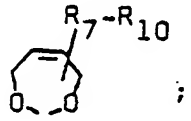
or



or



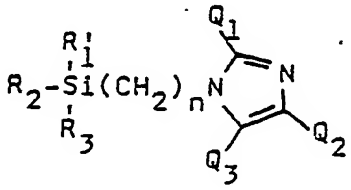
or



;

and salts thereof with protic acids and complexes with metal ions.

2. A compound of the formula:



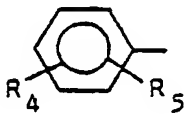
II

wherein

Q_1, Q_2 and Q_3 are independently H or CH_3;

n is 1;

R'_1 is C_6-C_{18} alkyl, C_3-C_6 cycloalkyl, naphthyl or



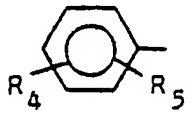
;

where

R_4 and R_5 are independently -H; halogen; $-OCH_3$; $-OCF_3$; $-SCH_3$; $-SO_2CH_3$; phenyl; phenyl substituted with halogen and/or

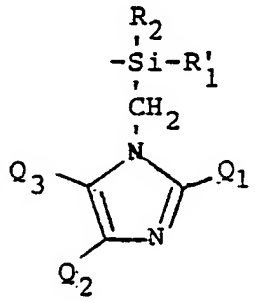
C_1-C_4 alkyl and/or $-CF_3$; phenoxy;
phenoxy substituted with halogen and/or
C_1-C_4 alkyl and/or $-CF_3$; $-CF_3$;
C_1-C_4 alkyl; or cyclohexyl;
with the proviso that for compounds of Formula II, both R_4 and R_5 may not simultaneously be H; and

R_2 and R_3 are independently C_1-C_6 alkyl, C_3-C_6 cycloalkyl, OR_6, or

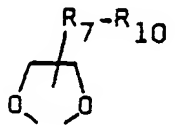


;

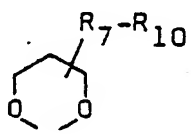
where R_4 and R_5 are as defined above except that said proviso does not apply, and R_6 is H or C_1-C_4 alkyl, or one R_6 group may be



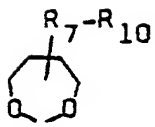
with the proviso that both R_2 and R_3 may not be OH; and R_2 and R_3 together may be a 1,2- or 1,3- or 1,4-glycol bridge or a 1,4 unsaturated glycol bridge which may optionally be substituted by up to four alkyl groups R_7-R_{10} that have a total of up to four carbon atoms, viz.



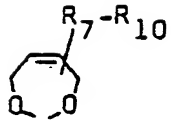
or



or



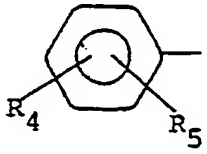
or



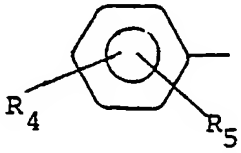
and salts thereof with protic acids and complexes with metal ions.

3. A compound of claim 1 or 2 wherein Q_1 and Q_2 are H.

4. A compound of claim 3 wherein R_1 or R_1' is

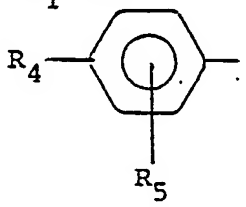


R_2 is C_1-C_4 alkyl or



and R_3 is C_1-C_4 alkyl.

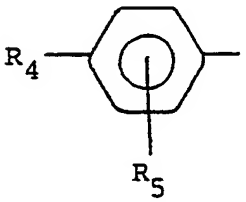
5. A compound of claim 4 wherein R_1 and R_1' are



where R_4 is H, F, Cl, Br or phenyl, and

R_5 is H, F, Cl or Br; and

R_2 is



or C_1-C_4 alkyl; and

R_3 is C_1-C_4 alkyl.

6. The compound of Claim 1 which is (1,1'-biphenyl-4-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)-silane.

7. The compound of Claim 1 which is bis(4-chlorophenyl)methyl(1H-1,2,4-triazol-1-ylmethyl)-silane.

8. The compound of Claim 1 which is [bis(4-fluorophenyl)]methyl(1H-1,2,4-triazol-1-ylmethyl)-silane.

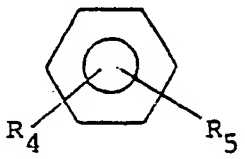
9. The compound of Claim 1 which is 4-fluorophenyl(methyl)phenyl(1H-1,2,4-triazol-1-ylmethyl)-silane.

10. The compound of claim 2 which is (2,4-dichlorophenyl)dimethyl(1H-imidazol-1-ylmethyl)silane.

11. A compound of claim 1 wherein:

Q_1 and Q_2 are H;

R_1 is C_2-C_{18} alkyl, C_3-C_6 cycloalkyl, naphthyl, or



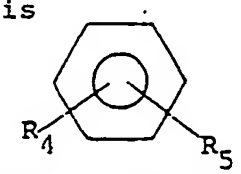
where R_4 and R_5 are independently -H, halogen, phenyl, $-OCH_3$, $-SCH_3$, phenoxy, $-CF_3$ or C_1-C_4 alkyl; and

R_1 and R_3 are independently C_1-C_6 alkyl, C_3-C_6 cycloalkyl, or OR_6, where R_6 is H or C_1-C_4 alkyl.

12. A compound of claim 2 wherein

Q_1, Q_2 and Q_3 are H;

R_1' is



where R_4 and R_5 are as defined in claim 11 but are not both H; and

R_2 and R_3 are independently C_1-C_4 alkyl or OR_6, where R_6 is H or C_1-C_4 alkyl.

13. A composition for controlling fungus

diseases comprising an effective amount of a fungicidal compound and at least one of the following: surfactant, solid or liquid inert diluent, characterised in

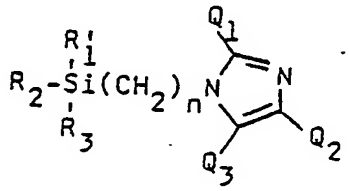
that said fungicidal compound comprises a compound of any of claims 1 to 12.

14. A method for controlling fungus diseases by applying to the locus to be protected an effective amount of a fungicidal compound, characterised in

that said fungicidal compound comprises a compound of any of claims 1 to 12.

15. A method for controlling fungus diseases by applying to the locus to be protected an effective amount of a fungicidal compound, characterised in

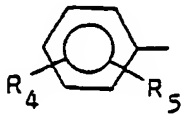
that said fungicidal comprises a compound of the formula:



wherein

Q_1, Q_2, Q_3, n, R_2, R_3, and R_6 are as defined in claim 2, and

R'_1 is C_2-C_{18} alkyl, C_3-C_6 cycloalkyl, naphthyl or

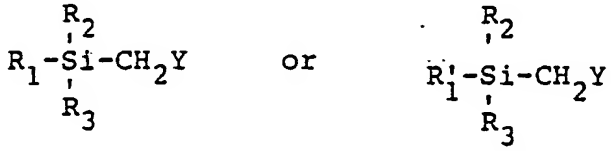
 ;

where

R_4 and R_5 are independently -H; halogen; $-OCH_3$; $-OCF_3$; $-SCH_3$; $-SO_2CH_3$; phenyl; phenyl substituted with halogen and/or C_1-C_4 alkyl and/or $-CF_3$; phenoxy; phenoxy substituted with halogen and/or

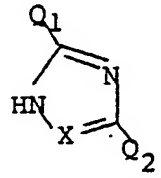
C_1-C_4 alkyl and/or $-CF_3$; $-CF_3$;
C_1-C_4 alkyl; or cyclohexyl; or a salt thereof with a protic acid or a complex thereof with a metal ion.

16. A process for preparing a compound of claim 1 or 2 which comprises reacting a silane derivative of formula



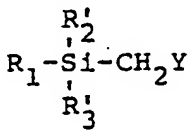
or

wherein R_1, R_1', R_2 and R_3 are as defined in claims 1 and 2 and Y is chlorine, bromine, iodine or arylsulfonyloxy, with a 1,2,4-triazole or imidazole of formula

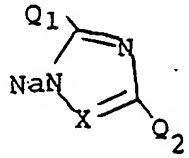


wherein Q_1 and Q_2 are independently H or CH_3 and X is H, CH or CCH_3, or with an alkali metal salt thereof.

17. A process for preparing a compound of claims 1 or 2 wherein R_2 and/or R_3 is OR_6 which comprises reacting a corresponding compound of formula



wherein R_2' is halogen or R_2 and R_3' is halogen or R_3, at least one of R_2 and R_3 being halogen, and Y is as defined in claim 15, with a triazole or imidazole sodium salt of formula



wherein X is N, CH or CCH_3, and reacting the intermediate so obtained with R_6 OH to obtain a compound

of claim 1 or 2 wherein R_2 and/or R_3 is R_6O;

R_1 having a value as defined for R_1' in claim 2 when X is CH or CCH_3.

18. A process for preparing a compound of claim 1 which comprises reacting 1) an intermediate selected from the group

$$Cl_3SiCH_2Cl,\ \ Cl_2\overset{R_3}{\underset{|}{Si}}CH_2Cl \text{ and } Cl-\overset{R_2}{\underset{R_3}{\overset{|}{\underset{|}{Si}}}}-CH_2Cl$$

in a suitable solvent with R_1M where M is Na, Li or MgX where X is Br, Cl, I, at a temperature of from -80° to 40°C to form a chloromethylsilane; and 2) reacting the chloromethylsilane with 1,2,4-triazole, its 3-methyl or 3,5-dimethyl derivative, or their alkali metal salts in polar aprotic solvents, ethers or ketones at 0° to 200°C; R_1, R_2 and R_3 being as defined in claim 1.

19. A process for preparing a compound of Claim 1 which comprises 1) reacting

$$R_1-\overset{Cl}{\underset{Cl}{\overset{|}{\underset{|}{Si}}}}CH_2Cl \qquad \text{or} \qquad R_1-\overset{R_2}{\underset{Cl}{\overset{|}{\underset{|}{Si}}}}-CH_2Cl$$

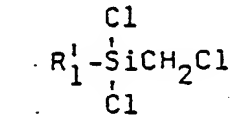
with R_6OH in a suitable solvent with a suitable base at a temperature of 0°-100°C to form an alkoxy or dialkoxy chloromethylsilane; and 2) reacting the chloromethylsilanes with 1,2,4-triazole, its 3-methyl or 3,5-dimethyl derivative, or their alkali metal salts in polar aprotic solvents, ethers or ketones at 0° to 200°C; R_1, R_2 and R_6 being as defined in claim 1.

20. A process for preparing a compound of claim 2 which comprises reacting 1) an intermediate selected from the group

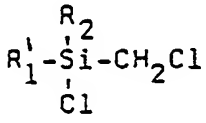
$$Cl_3SiCH_2Cl,\ \ Cl_2\overset{R_3}{\underset{|}{Si}}CH_2Cl \text{ and } Cl-\overset{R_2}{\underset{R_3}{\overset{|}{\underset{|}{Si}}}}-CH_2Cl$$

in a suitable solvent with $R_1'M$ where M is Na, Li or MgX where X is Br, Cl, I, at a temperature of from -80° to 40°C to form a chloromethylsilane; and 2) reacting the chloromethylsilane with imidazole, its 2-methyl, 2,4-dimethyl, 4,5-dimethyl, and 2,4,5-trimethyl derivatives, or their alkali metal salts in polar aprotic solvents, ethers or ketones at 0° to 200°C; R_1', R_2 and R_3 being as defined in claim 2.

21. A process for preparing a compound of claim 2 which comprises 1) reacting



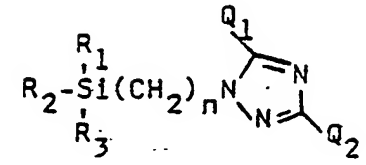
and



with R_6OH in a suitable solvent with a suitable base at a temperature of 0° to 100°C to form an alkoxy or dialkoxy chloromethylsilane; and 2) reacting the chloromethylsilane with imidazole, its 2-methyl, 2,4-methyl, 4,5-methyl, and 2,4,5-trimethyl derivatives, or their alkali metal salts in polar aprotic solvents, ethers or ketones at 0° to 200°C; R_1', R_2 and R_6 being as defined in claim 2.

Claims: AT

1. A process for the preparation of a compound of the formula:



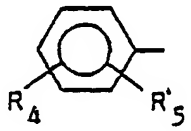
I

wherein

Q_1 and Q_2 are independently H or CH_3;

n is 1;

R_1 is C_2-C_{18} alkyl, C_3-C_6 cycloalkyl, naphthyl, or

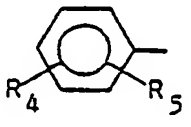


;

where

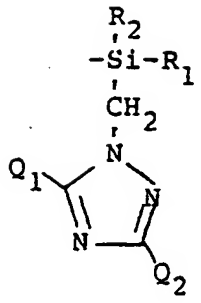
R_4 and R_5 are independently -H; halogen; $-OCH_3$; $-OCF_3$; $-SCH_3$; $-SO_2CH_3$; phenyl; phenyl substituted with halogen and/or C_1-C_4 alkyl and/or $-CF_3$; phenoxy; phenoxy substituted with halogen and/or C_1-C_4 alkyl and/or $-CF_3$; $-CF_3$; C_1-C_4 alkyl; or cyclohexyl;

R_2 and R_3 are independently C_1-C_6 alkyl, C_3-C_6 cycloalkyl, OR_6, or

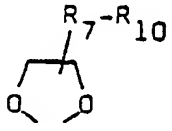
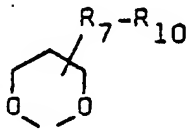


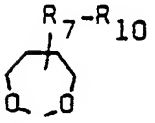
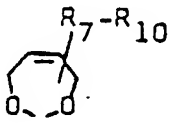
;

where R_6 is H or C_1-C_4 alkyl, or one R_6 group may be



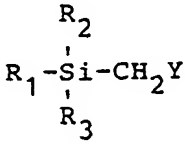
with the proviso that both R_2 and R_3 may not be OH; and R_2 and R_3 together may be a 1,2- or 1,3- or 1,4-glycol bridge or a 1,4 unsaturated glycol bridge which may optionally be substituted by up to four alkyl groups R_7-R_{10} that have a total of up to four carbon atoms,

 or  or

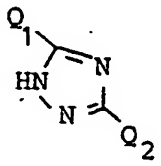
 or 

and salts thereof with protic acids and complexes with metal ions, which comprises

(a) reaction of a silane derivative of formula

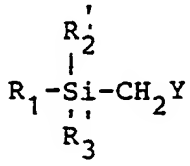


wherein R_1, R_2 and R_3 are as defined above and Y is chlorine, bromine or arylsulfonyloxy, with a 1,2,4-triazole of formula

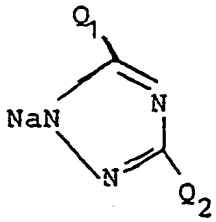


wherein Q_1 and Q_2 are as defined above or with an alkali metal salt thereof; or

(b) reacting a corresponding compound of formula

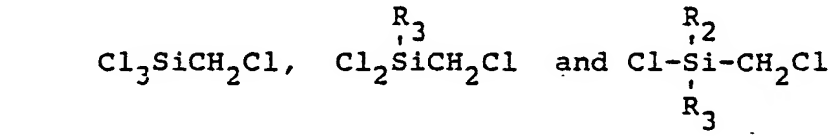


wherein R_1 and Y are as defined above, R_2' is halogen or R_2 and R_3 is halogen or R_3, at least one of R_2' and R_3' being halogen, with a triazole sodium salt of formula



wherein Q_1 and Q_2 are as defined above, and reacting the intermediate so obtained with R_6OH to obtain a product of formula I wherein R_2 and/or R_3 is R_6O.

2. A process for the preparation of a compound of formula I as defined in claim 1, which comprises reacting 1) an intermediate selected from the group



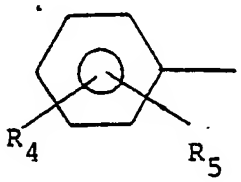
Cl_3SiCH_2Cl, $Cl_2\overset{R_3}{\underset{|}{Si}}CH_2Cl$ and $Cl-\overset{R_2}{\underset{R_3}{\overset{|}{\underset{|}{Si}}}}-CH_2Cl$

in a suitable solvent with R_1M where M is Na, Li or MgX where X is Br, Cl, I, at a temperature of from -80°C to 40°C to form a chloromethylsilane; and 2) reacting the chloromethylsilane with 1,2,4-triazole, its 3-methyl or 3,5-dimethyl derivative, or their alkali metal salts in polar aprotic solvents, ethers or ketones at 0° to 200°C; R_1, R_2 and R_3 being as defined in claim 1.

3. The process of claim 1 or claim 2 wherein:

Q_1 and Q_2 are H;

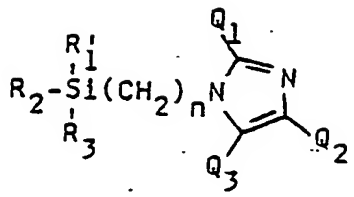
R_1 is C_2-C_{18} alkyl, C_3-C_6 cycloalkyl, naphthyl, or



where R_4 and R_5 are independently -H, halogen, phenyl, $-OCH_3$, $-SCH_3$, phenoxy, $-CF_3$ or C_1-C_4 alkyl; and

R_1 and R_3 are independently C_1-C_6 alkyl, C_3-C_6 cycloalkyl, or OR_6, where R_6 is H or C_1-C_4 alkyl.

4. A process for the preparation of a compound of the formula:



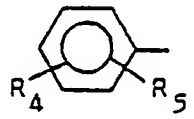
II

wherein

Q_1, Q_2 and Q_3 are independently H or CH_3;

n is 1;

R'_1 is C_6-C_{18} alkyl, C_3-C_6 cycloalkyl, naphthyl or



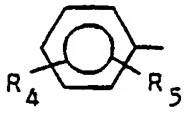
;

where

R_4 and R_5 are independently -H; halogen; $-OCH_3$; $-OCF_3$; $-SCH_3$; $-SO_2CH_3$; phenyl; phenyl substituted with halogen and/or C_1-C_4 alkyl and/or $-CF_3$; phenoxy; phenoxy substituted with halogen and/or C_1-C_4 alkyl and/or $-CF_3$; $-CF_3$; C_1-C_4 alkyl; or cyclohexyl;

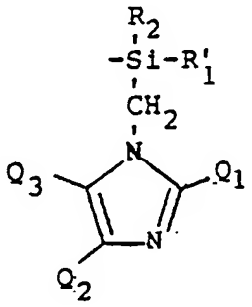
with the proviso that for compounds of Formula II, both R_4 and R_5 may not simultaneously be H; and

R_2 and R_3 are independently C_1-C_6 alkyl, C_3-C_6 cycloalkyl, OR_6, or

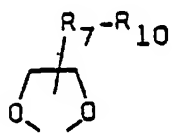
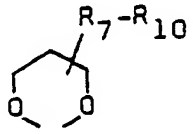


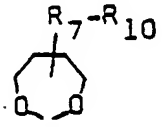
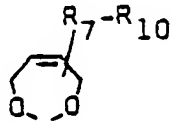
;

where R_4 and R_5 are as defined above except that said proviso does not apply and R_6 is H or C_1-C_4 alkyl, or one R_6 group may be



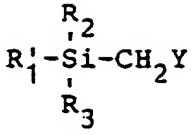
with the proviso that both R_2 and R_3 may not be OH; and R_2 and R_3 together may be a 1,2- or 1,3- or 1,4-glycol bridge or a 1,4 unsaturated glycol bridge which may optionally be substituted by up to four alkyl groups R_7-R_{10} that have a total of up to four carbon atoms, viz

 or  or

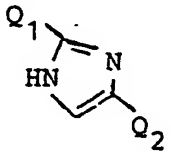
 or 

and salts thereof with protic acids and complexes with metal ions, which comprises

(a) reacting a silane derivative of formula

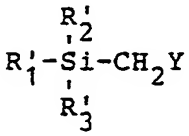


wherein R_1', R_2 and R_3 are as defined above and Y is chlorine, bromine, iodine or arylsulfonyloxy, with an imidazole of formula

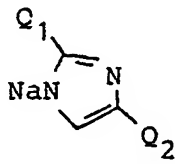


wherein Q_1 and Q_2 are as defined above, or with an alkali metal salt thereof, or

(b) reacting a corresponding compound of formula



wherein R_1' and Y are as defined above, R_2' is halogen or R_2, R_3' is halogen or R_3, at least one of R_2' and R_3' being halogen, with an imidazole sodium salt of formula



wherein Q_1 and Q_2 are as defined above, and reacting the intermediate so obtained with R_6OH to obtain a compound of formula II wherein R_2 and/or R_3 is R_6O.

5. A process for the preparation of a compound of formula II as defined in claim 4 which comprises reacting 1) an intermediate selected from the group

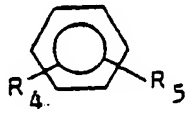
Cl_3SiCH_2Cl, $Cl_2\overset{R_3}{\underset{|}{Si}}CH_2Cl$ and $Cl-\overset{R_2}{\underset{R_3}{\overset{|}{\underset{|}{Si}}}}-CH_2Cl$

in a suitable solvent with $R_1'M$ where M is Na, Li or MgX where X is Br, Cl, I, at a temperature of from -80°C to 40°C to form a chloromethylsilane; and 2) reacting the chloromethylsilane with imidazole, its 2-methyl, 2,4-dimethyl, 4,5-dimethyl, and 2,4,5-trimethyl derivatives, or their alkali metal salts in polar aprotic solvents, ethers or ketones at 0° to 200°C; R_1', R_2 and R_3 being as defined in claim 2.

6. The process of claims 4 or 5 wherein

Q_1, Q_2 and Q_3 are H;

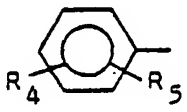
R_1' is



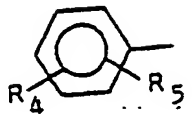
where R_4 and R_5 are as defined in claim 3 but are not both H; and

R_2 and R_3 are independently C_1-C_4 alkyl or OR_6, where R_6 is H or C_1-C_4 alkyl.

7. The process of any of claims 1-6 wherein Q_1 and Q_2 are H, R_1 or R_1' is



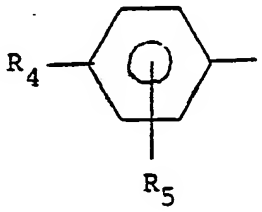
R_2 is C_1-C_4 alkyl or



and R_3 is C_1-C_4 alkyl.

8. The process of claim 7 wherein

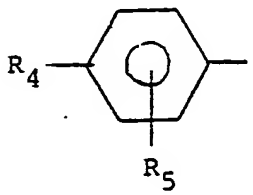
R_1 and R_2' are



where R_4 is H, F, Cl, Br or phenyl, and

R_5 is H, F, Cl or Br; and

R_2 is



or C_1-C_4 alkyl; and

R_3 is C_1-C_4 alkyl.

9. The process of claim 1 or 4 wherein the product is selected from:

(1,1'-bi-phenyl-4-yl)dimethyl(1H-1,2,4-triazol-1-ylmethyl)-silane;

bis(4-chlorophenyl)methyl(1H-1,2,4-triazol-1-ylmethyl)-silane;

[bis(4-fluorophenyl)]methyl(1H-1,2,4-triazol-1-ylmethyl)-silane;

4-fluorophenyl(methyl)phenyl(1H-1,2,4-triazol-1-ylmethyl)-silane; and

(2,4-dichlorophenyl)dimethyl(1H-imidazol-1-ylmethyl)silane.

10. A method for controlling fungus diseases by applying to the locus to be protected an effective amount of a fungicidal compound, characterised in

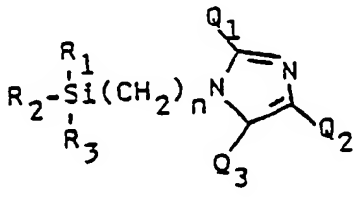
that said fungicidal compound comprises a compound of formula I as defined in any of claims 1-3 or 7-9.

11. A method for controlling fungus diseases by applying to the locus to be protected an effective amount of a fungicidal compound, characterised in

that said fungicidal compound comprises a compound of formula II as defined in any of claims 4-9.

12. A method for controlling fungus diseases by applying to the locus to be protected an effective amount of a fungicidal compound, characterised in

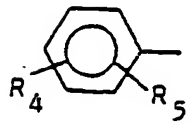
that said fungicidal compound comprises a compound of formula :



wherein

Q_1, Q_2, Q_3, n, R_2, R_3 and R_6 are as defined in claim 2, and

R_1' is C_2-C_{18} alkyl, C_3-C_6 cycloalkyl, naphthyl or



;

where

R_4 and R_5 are independently -H; halogen; $-OCH_3$; $-OCF_3$; $-SCH_3$; $-SO_2CH_3$; phenyl; phenyl substituted with halogen and/or C_1-C_4 alkyl and/or $-CF_3$; phenoxy; phenoxy substituted with halogen and/or C_1-C_4 alkyl and/or $-CF_3$; $-CF_3$; C_1-C_4 alkyl; or cyclohexyl; or a salt thereof with a protic acid or a complex thereof with a metal ion.

(19) Europäisches Patentamt
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C 07 F 7/18, A 01 N 55/00

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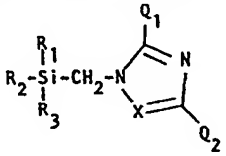
(54) **Fungicidal 1,2,4-triazole and imidazole derivatives.**

(57) 1,2,4-Triazole and imidazole derivatives of the general formula



wherein R_1, R_2 and R_3 are alkyl, naphthyl or optionally substituted phenyl; or R_2 and R_3 may be hydroxy or alkoxy;
X is N, CH or CCH_3; and
Q_1 and Q_2 are H or CH_3;
are effective fungicides for controlling fungi in a plant locus. They may be formulated for use in conventional manner.

The compounds may be made e.g. by reacting a suitable chloromethylsilane with a suitable imidazole or 1,2,4-triazole.

EP 0 068 813 A3

European Patent Office

EUROPEAN SEARCH REPORT

0068813
Application number

EP 82 30 3281

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. ³)
A	FR-A-1 360 395 (DOW CORNING CORP.) *Page 12; claims 6,9; page 6, example 3*	2	C 07 F 7/08 C 07 F 7/18 A 01 N 55/00
A	FR-A-2 269 532 (DYNAMIT NOBEL AG) *Page 13, claims 1,2*	2	
A	CHEMICAL ABSTRACTS, vol. 86, no. 23, 6th June 1977, page 567, no. 171534g, Columbus Ohio (USA); V.D.SHELUDYAKOV et al.: "Synthesis of silicon-containing derivatives of 3,5-dimethylpyrazole, imidazole, and benzimidazole" & ZH. OBSHCH. KHIM. 1977, 47(1), 90-6. *Abstract*	2,16, 17	
D,A	US-A-3 692 798 (SANDOR BARCZA) *Column 5; claim 1*	2,15-17	C 07 F 7/00
A	CHEMICAL ABSTRACTS, vol. 78, no. 5, 5th February 1973, page 523, no. 29989a, Columbus Ohio (USA); & SU - A - 346 306 (MIRONOV, V.F. et al.) (28-07-1972) *Abstract*	1,2	

TECHNICAL FIELDS SEARCHED (Int. Cl. ³)

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	01-12-1982	SUTER M.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

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